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A STUDY OF THREE VARIETIES OF JUTE

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TWO PLATES

INTRODUCTION

The importance of jute as a source of fiber for the manufacture of gunny sacks cannot be overemphasized. Its culture has been found successful in this country and the yields obtained in trial cultures conducted by the Bureau of Plant Industry "compare favorably with the yield being obtained in India." (2)

The Philippines has been a regular importer of jute bags and burlap to supply its needs for containers of rice, corn, and sugar. The value of the importation reached about ten million pesos annually during the postwar period. The expected greater local production of rice and other cereals, beans, sugar, and other crops will further increase the demand for jute sacks and because of this, the administration was prompted to lay some emphasis on the culture of the jute plant and to make a plan for its extensive production. In fact the senior author recommended as far back as 1936 that jute be one of the Philippine major crops since we were importing enormous quantities of jute bags and burlap. He emphasized that it is a crop suitable to precede cotton and other dry season crops. Moreover, it is a crop less susceptible to pests and diseases than cotton and it is less discriminating in its cultural requirements. It is highly adapted in this country during the rainy season as it entails less risk under adverse conditions.

Studies conducted by the writers during the Japanese occupation when the need for fiber for the manufacture of sacks was urgent revealed that the Red and Green varieties of *Corchorus*

olitorius were decidedly better in yield of fiber than the Indian jute, *C. capsularis*. However, no data could be given to support these findings as all the records were destroyed during the fight for the liberation of Manila in 1945.

The present study which was made to verify previous observations was conducted to determine the best variety to raise among those now under cultivation by the Bureau of Plant Industry. It was conducted in Lamao Experiment Station, Lamao, Limay, Bataan, from September to December, 1947.

MATERIALS AND METHODS

Description of materials.—The jute varieties tested were Native Red, Native Green, both belonging to the indigenous species *Corchorus olitorius*, and an exotic variety of the species *C. capsularis* which was introduced from India in 1936. The Native Red and Native Green jutes have respectively red and green stems and their fruits are long (5 to 6 centimeters), cylindrical with five or six cells where the seeds are enclosed and an elongated beak (Plate 1, fig. 1, *a*). The Indian variety on the other hand has green stem with purple leaf petioles. The fruits of this variety are small, wrinkled, and nearly globular (Plate 1, fig. 1, *b*) 2 to 2.5 centimeters long with five or six flat-topped seed cells. (2) The young top shoots of both the native varieties are valuable for food, while those of the Indian variety are bitter, rough, and dry.

The seeds used were obtained from plants grown in the Central Experiment Station, Manila, in the summer of 1947.

Land preparation.—The land used had an area of 130 square meters, with a sandy loam soil, and planted to corn during the previous season. The field was plowed and harrowed twice, leaving one week as interval between each plowing. After the land was prepared, it was divided into five lots which were separated by paths 50 centimeters wide. These lots were further subdivided into plots, three to a lot, with dimensions 10 meters long and 40 centimeters wide each and were separated by paths 30 centimeters wide.

Plating and care of culture.—The seeds were drilled on September 20, 1947, in shallow furrows 20 centimeters apart. There were two rows in each plot. The varieties tested were alternately distributed to the different plots. After the seeds were drilled, they were covered with well-pulverized soil about an inch thick.

When the plants were 5 centimeters tall, they were thinned to stand 5 centimeters between plants in the row in order to insure uniform number and distance between plants in the row in all plots. After thinning, compost was uniformly applied at the rate of 500 kilograms per hectare. Thereafter, weeding was done whenever necessary and irregation water applied regularly when there was no rain during the growing period. Efforts were exerted to have all plots receive equal amounts of water.

Characters studied.—The characters studied were earliness of maturity, height of plants at blooming stage, number and length of branches, weight per 100 fresh stalks (whole plants), percentage of dry fiber of each variety, and yield of fresh stalks and dry fiber per hectare.

On October 23, 1947, or 43 days after sowing, the percentage of plants in bloom in all plots was determined to serve as an index on earliness of maturity. The blooming stage is considered as the maturity stage of jute for fiber production as it is at this time that the plants are harvested. The data for this phase of the work were obtained by counting the number of plants in one meter of each plot and the number of plants that had flowers in the same area. As on this date, there were no plants of the Indian variety that were in bloom, this phase of the study for this variety was postponed to October 29, 1947, or six days later.

Just before harvesting, the height of 50 plants taken at random in each plot was measured with the use of a wooden rod calibrated in centimeters. Then the branches of all plants were counted and the length of 100 branches at random in each plot was measured.

The native varieties were harvested on November 19, 1947, or 70 days after planting, when all plants were in bloom. The Indian variety was harvested five days later, or on November 24, 1947, when the plants were at the same stage as those of the native varieties were when cut. The plants harvested from each plot were bundled separately. The bundles were weighed and counted to get the necessary data for the computation of the weight per one hundred stalks. The "lapnit,"[1] or ribbons, were extracted, bundled separately, and labeled with galvanized iron tags bearing numbers corresponding to the number of the plot

[1] Fillets or strips of the bark or skin after removing them from the stalks.

from which the ribbons were obtained. The ribbons were soaked in water to ret. In all cases the retting period was twelve days. After retting, the fibers were washed thoroughly and uniformly dried in the sun, and later weighed.

RESULTS AND DISCUSSION

The results of the experiment are presented in Tables 1 to 8 and summarized in Table 9. Two plates are also included.

Earliness of maturity.—Table 1 shows that both the Native Red and the Native Green bloomed earlier than the Indian variety. Determinations made forty-three days after planting revealed that 75.28 ± 5.03 per cent of plants of the Native Red were already in bloom; 63.08 ± 2.85 per cent of the Native Green; but none yet of the Indian variety. Even a later determination (forty-nine days after sowing) showed only 43.09 ± 2.34 per cent of the Indian plants in bloom which was very much lower than the figures obtained from an earlier counting on the two varieties. However, whether the Native Red blooms earlier or not than the Native Green is doubtful as their difference when compared with each other statistically was only 12.00 ± 5.82 per cent (Table 9) which may be considered insignificant.

TABLE 1.—*Comporative earliness of maturity for fiber of three varieties of jute.*

Variety	Mean percentage of plants in bloom 43 days after planting	Standard deviation	Coefficient of variability
		Per cent	*Per cent*
Native Red	75.28 ± 5.08	16.85 ± 3.60	22.38 ± 5.01
Native Green	63.08 ± 2.85	9.44 ± 2.04	14.96 ± 3.26
Indian [a]	43.09 ± 2.31	7.76 ± 1.66	18.01 ± 3.96

[a] As there was no plant in bloom 43 days after planting, the data were taken a few days later, or 49 days after sowing.

Height.—Height is an important factor to consider in the selection of a jute variety. Other things being equal, the taller a plant is the more fiber is extracted from it and at the same time, the fiber obtained is of higher quality by reason of greater length. The data presented in Table 2 show that in seventy days after planting, Native Red had a height of 81.5 ± 3.3 centimeters; Native Green, 81.0 ± 5.4 centimeters; and Indian, 78.4 ± 0.6 centimeters. Compared with one another, however, the three varieties did not have significant differences in height.

TABLE 2.—*Average height at blooming stage of three varieties of jute.*

Variety	Mean	Standard deviation	Coefficient of variability
	Centimeters	*Centimeters*	*Per cent*
Native Red	81.5±3.3	10.34±2.21	12.69±2.75
Native Green	81.0±5.4	18.03±3.85	22.26±4.92
Indian	78.4±0.6	1.86±0.40	2.38±0.51

Branching.—An ideal jute plant is described as, among other things, free from sideshoots or branches. Branching breaks the continuity of the ribbon and consequently of the fiber, thus lowering both quantity and quality of the product. It is very much easier to remove the "lapnit," or ribbons, from a jute plant without branches than from a branchy one. Moreover, even if the stalks are soaked to ret in water without separating the "lapnit" from the woody portion of the stem, great difficulty is met in separating the fiber from the wood in branchy plants. This observation agrees with the findings of Varada and Patel. (8)

TABLE 3.—*Average number of branches per plant of three varieties of jute.*

Variety	Mean	Standard deviation	Coefficient of variability
	Branches	*Branches*	*Per cent*
Native Red	0.71±0.06	0.20±0.04	28.80±6.02
Native Green	0.44±0.01	0.04±0.01	9.78±0.13
Indian	2.80±0.07	0.22+0.05	7.97±1.70

Observation showed that the Indian was the most branchy, while the Native Green was the least (Table 3). Table 4, however, shows that although the Indian jute had the most branches, these were short, 4.4±0.1 centimeters; the Native Red had the longest, 31.3±0.6 centimeters; while the Native Green had a mean length of branches of 25.2±0.8 centimeters. The foregoing data show the advantages of the native varieties over the Indian because the former have less branches, the "lapnit" of which can be conveniently extracted. In other words, although the fiber obtained from the native varieties was short, such deficiency was made up by the fiber extracted from the long branches. While in the case of the Indian jute, a deterioration of quality caused by branching cannot be made up by quantity as no fiber can be conveniently extracted from the short branches.

TABLE 4.—*Average length of branches of three varieties of jute.*

Variety	Mean	Standard deviation	Coefficient of variability
	Centimeters	*Centimeters*	*Per cent*
Native Red	31.3±0.6	2.12±0.45	6.79±1.45
Native Green	25.2±0.8	2.65±0.56	10.51±2.27
Indian	4.4±0.1	0.24±0.05	4.90±1.04

Weight of stalks.—In this study, the weight of 100 fresh stalks was used as an index on size. Table 5 shows that Native Red jute plants had the largest stalks, one hundred of which weighed 2.98±0.03 kilograms; Native Green, second, 2.35±0.07 kilograms; and Indian, last, 1.86±0.08 kilograms.

TABLE 5.—*Comparative weight per hundred stalks of three varieties of jute.*

Variety	Mean	Standard deviation	Coefficient of variability
	Kilograms	*Kilograms*	*Per cent*
Native Red	2.98±0.03	0.12±0.03	3.94±0.84
Native Green	2.35±0.07	0.23±0.05	9.90±2.11
Indian	1.86±0.08	0.30±0.06	14.44±0.12

Tonnage.—The data presented in Table 6 show that Native Red had a computed yield per hectare of 22.4±0.7 tons of fresh stalks (with leaves and branches); Native Green, 17.0±0.4 tons; and Indian, 11.3±0.3 tons. These yields are low in comparison with those reported by Garrido(2) as the plants for this experiment were planted in September, three months after the regular planting season.

TABLE 6.—*Estimated yield of fresh stalks per hectare of three varieties of jute.*

Variety	Mean	Standard deviation	Coefficient of variability
	Tons	*Tons*	*Per cent*
Native Red	22.4±0.7	2.35±0.50	10.51±2.27
Native Green	17.0±0.4	1.30±0.28	7.67±1.64
Indian	11.3±0.3	1.08±0.23	9.53±2.03

In this connection it may be worth mentioning that observations showed that jute is a seasonal plant and in places with the first type of rainfall, it should be planted at the beginning of the rainy season. If it is planted towards the end of the rainy season, no amount of irrigation or fertilizer could delay its

maturity with the result that short stalks are produced as the plants do not have enough time to enlarge and elongate their stems before they bloom. Garrido(2) found that jute planted in May or June matured for fiber production in from three to three and a half months growth with tall (about 2 meters long), fine, slender stalks or straw and the yield per hectare ranged from 40 to 50 tons. The reason for this is that the plants had longer period for the enlargement and elongation of the stalks. The plants herein reported matured for fiber production in about two months.

Early maturity is believed to be a physiological response of the plants when planted out of season. Under this condition, it was noted that the sexual phase or the production of flowers and fruits continued vigorously at the expense of vegetative growth which was checked. Moreover, the plants under study in this experiment were planted in months having slightly shorter day periods than the regular season (May to August). Consequently, the plants had short stalks, short and few internodes, numerous branches, fine stems, and thus were short and bushy (Plate 2).

Yield of fiber.—In previous culture trials Garrido(2) estimated the percentage of fiber as 5 for the native varieties. The percentage of fiber (Plate 1, fig. 2) herein reported is comparatively lower owing, perhaps, to difference in season of planting as has already been mentioned. Furthermore, it was noted that the stalks, besides being short, bushy and small, were lanky and hard, showing evidence of lack of enough moisture. This made the separation of the "lapnit," from the wood more difficult and consequently a very small portion, only about $\frac{1}{3}$, of the ribbons was removed. This accounted for much lower percentage of fiber.

Table 7 shows that the Native Red had the highest percentage of fiber, 1.15±0.01 of the weight of fresh stalks; Native Green, second 1.11±0.03; and Indian last, 0.95±0.08.

TABLE 7.—*Percentage of fiber of three varieties of jute.*

Variety	Mean	Standard deviation	Coefficient of variability
	Per cent	*Per cent*	*Per cent*
Native Red	1.15±0.01	0.05±0.01	4.53±0.97
Native Green	1.11±0.03	0.11±0.03	10.49±2.26
Indian	0.95±0.08	0.28±0.06	29.52±6.82

With a higher tonnage and a higher percentage of fiber than the other two varieties, Native Red had the highest computed yield of dry fiber per hectare, 259.0±10.8 kilograms as compared with 190.1±8.5 kilograms for Native Green and 105.5±7.2 kilograms for Indian (Table 8).

TABLE 8.—*Estimated yield of fiber per hectare of three varieties of jute.*

Variety	Mean	Standard deviation
	Kilograms	*Kilograms*
Native Red	259.0±10.8	35.73±7.62
Native Green	190.1± 8.5	28.12±5.99
Indian	105.5± 7.2	23.71±5.06

TABLE 9.—*Summary of Tables 1 to 8 comparing the means of the characters of three jute varieties.*

Characters studied	Varieties: Native Red	Native Green	Indian
Mean percentage of plants in bloom 43 days after planting	75.28± 5.08	63.08±2.85	43.09±2.34
Average height at blooming stage, centimeters	81.5 ± 3.3	81.0 ±5.4	78.4 ±0.6
Average number of branches per plant	0.71± 0.06	0.44±0.01	2.80±0.07
Average length of branches, centimeters	31.3 ± 0.6	25.2 ±0.8	4.4 ±0.1
Weight per hundred stalks, kilograms	2.98± 0.03	2.35±0.07	1.86±0.08
Estimated yield of fiber per hectare, tons	22.4 ± 0.7	17.0 ±0.4	11.3 ±0.3
Percentage of fiber	1.15± 0.01	1.11±0.03	0.95±0.08
Estimated yield of fiber per hectare, kilograms	259.0 ±10.8	190.1 ±8.5	105.5 ±7.2

Characters studied	Difference: Native Green versus Native Red	Native Red versus Indian	Native Green versus Indian
Mean percentage of plants in bloom 43 days after planting	[a]12.20± 5.82	(b)	(b)
Average height at blooming stage, centimeters	[a]0.5 ± 6.3	[a]3.1 ± 3.2	[a]2.6 ± 5.4
Average number of branches per plant	[c]0.27± 0.06	[c]2.09± 0.09	[c]2.36± 0.07
Average length of branches, centimeters	[c]6.1 ± 0.06	[c]26.9 ± 0.09	[c]20.8 ± 0.07
Weight per hundred stalks, kilograms	[c]0.63± 0.08	[c]1.12± 0.09	[c]0.49± 0.11
Estimated yield of stalks per hectare, tons	[c]5.4 ± 0.8	[c]11.1 ± 0.8	[c]5.7 ± 0.5
Percentage of fibers	[a]0.04± 0.03	[c]0.20± 0.08	[a]0.16± 0.08
Estimated yield of fiber per hectare, kilograms	[c]68.9 ±12.81	[c]153.5 ±12.20	[c]84.6 ±10.17

[a] Insignificant.

[b] No statistical comparison was made of the Native Red and Native Green with the Indian variety as the data for the latter was taken six days later.

[c] Significant.

SUMMARY AND CONCLUSIONS

The results of a study of three varieties of jute now under cultivation by the Bureau of Plant Industry are reported in this

paper. From the data obtained, the following summary and conclusions are made:

1. The Native Green and Native Red matured at the same time. The Indian matured about a week later.

2. There were no significant differences in height of the plants at blooming stage of the three varieties when compared with one another.

3. The Indian jute was the most branchy, but the Native Red and Native Green plants had much longer branches.

4. The Native Red ranked first in weight of stalks, the Native Green, second, and the Indian, last.

5. The Native Red had the highest tonnage and the largest yield of fiber per hectare, with the Native Green, second, and the Indian, last.

6. There were no significant differences in the percentage of fiber of the three varieties when compared with one another.

7. Jute is a highly seasonal plant which should be planted in the Philippines at the beginning of the rainy season: Since the results show that our two indigenous jute varieties, the Native Red and Native Green, had the highest yield per hectare respectively, the authors desire to recommend at present the use of these varieties for extensive production until better strains are developed either through breeding or introduction.

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ILLUSTRATIONS

PLATE 1

FIG 1. The panicles of jute plants. *a*, the native variety, *C. olitorious*, with long and cylindrical capsules; *b*, the Indian variety, *C. capsularis*, with small, wrinkled and nearly globular capsules.

2. Fibers of the three varieties of jute. *a* and *b*, the Native red; *c* and *d*, the Indian; *e* and *f*, the Native green. Each bundle was obtained from 100 stalks.

PLATE 2

A view of the experiment plots, showing bushy jute plants with small and short stalks together with numerous branches.

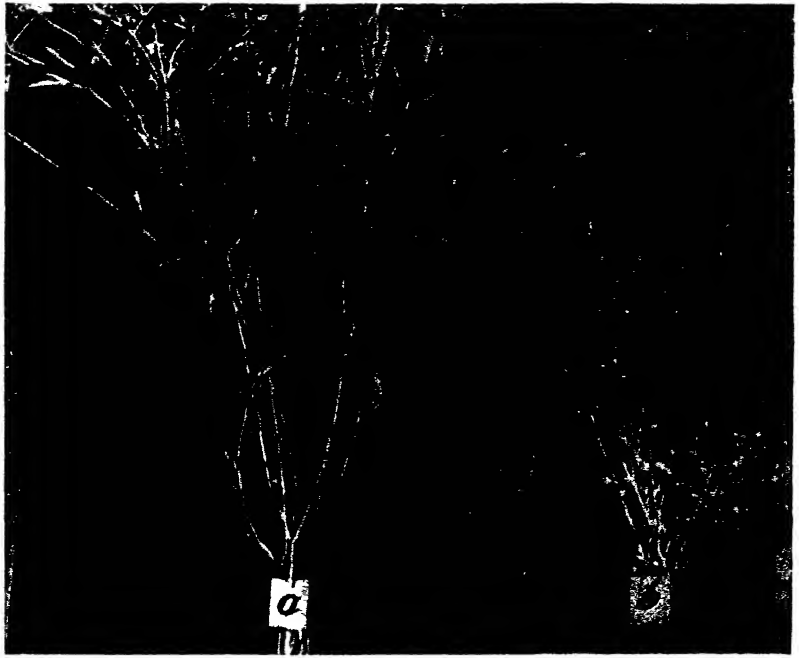

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PLATE 1.

PLATE 2.

A STUDY ON THE EFFECTS OF REMOVING HALF OF THE SEED UPON THE GERMINATION, GROWTH AND YIELD OF PEANUT

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Peanut is now extensively grown in the Islands. According to the 1939 census, 12,173 hectares were planted to this crop in that year. Peanut as a human food has remarkable nutritive values. During the Japanese occupation, when food supplies were running very low and the food prices very high, the problem of securing foods became so acute that people were forced to eat foods which were not commonly used or utilized at all before the war, just to satisfy their hunger. In times of emergency, such as those obtaining during the occupation, every form of food saving counts.

The usual way of growing peanut is to plant the whole seed. If it be possible to grow peanut using only half seeds, there would be a saving of about 50 per cent of the seed material which could be used as food if desired.

The object of this study was to find out the effects of removing half of the seed upon the germination, growth, and yield of peanut. The experiment was conducted in the Central Experiment Station at San Andres, Bureau of Plant Industry, Manila, from May 31, 1944 to September 26, 1944.

MATERIALS AND METHODS

The peanut used in this experiment was of the Tirik variety. The pods were shelled by pressing them between the fingers. Then the seed were selected and with the use of the thumbs and forefingers the longitudinal half of each, the half which did not retain the germ, was removed. This portion represents about 47.16 per cent by weight of the entire seed. The saving is equivalent to 14 15 kilograms of seed per hectare, or 172,223 kilograms of seed needed to plant the 1939 acreage, based on the old rate of seeding of 30 kilograms per hectare.

The field was plowed two times after clearing. Each plowing was followed by a thorough harrowing, after which furrows about 70 centimeters apart were laid out. The field was then divided into eight equal plots, each of which was in turn equally subdivided into two lots. Whole seeds (as control) and the half seeds were assigned at random to the lots in the different plots.

The seeds were planted on May 31, 1944, in hills spaced 25 centimeters apart in the furrow. Three seeds were planted on each hill and covered with soil.

The plants were hilled up with the native plow. Occasional hoeing of weeds between the plants was done.

At maturity the vines were measured from the base to the terminal bud. After harvesting they were weighed separately. The plants were harvested on September 25 and 26, 1944 by digging the pods with a spading fork. To remove the adhering soil particles the plants were shaken and spread on the ground for a little while to wilt. The pods were picked, washed, and dried in the sun. The harvests from the whole and half seeds in the different plots were weighed separately, and the mature, immature, and undeveloped pods were counted separately.

RESULTS AND DISCUSSION

FIELD OBSERVATION

Both the whole and half seeds germinated about the same time and it took them 4 to 5 days to germinate. During the first four weeks there was a difference in growth between the two treatments. The plants from the whole seeds appeared much better than those from the half. Later on, however, there was little or no difference in growth observed between the two treatments as the plants in the latter were then just as vigorous as the plants in the former.

Table 1 shows the number of seeds that germinated from the whole and half seeds in the different plots. The germinated seeds ranged from 28 to 30 and 25 to 28 in the whole and half, respectively, or an average of 29 seeds in the former and 26 in the latter. The whole seeds had a percentage germination of 98.75 and the half, 87.08. The difference between the means of the germinated seeds in the two treatments was highly significant.

TABLE 1.—*Number of seeds that germinated from whole and half seeds in eight plots.*

Treatment	Number of replication	Degree of freedom	No. of seeds germinated in plots —							
			1	2	3	4	5	6	7	8
Whole	8	7	29	28	30	30	30	30	30	30
Half	8	7	25	26	28	25	24	28	27	26

Treatment	Total	Mean	Sum of squares
Whole	287	29.625	3.875
Half	209	26.125	14.875

Mean difference: 3.5 seeds
Significance of difference: Highly significant.

On June 24, 1944 some plants began to flower. There were more plants from the whole seeds that flowered than from the half as shown in Table 2. Considering the total number of plants that had flowered in the different plots, there were 87 from the whole and 17 from the half. In other words the number in the former was more than five times the latter. Of all the seeds that germinated, 36.71 per cent had flowered from the whole and 8.13 per cent from the half. The difference between their means was 8.75, which is highly significant.

TABLE 2.—*Number of plants that flowered on June 24, 1944 from the germinated seeds.*

Treatment	Number of replication	Degree of freedom	No. of plant flowered in plots							
			1	2	3	4	5	6	7	8
Whole	8	7	15	10	9	10	7	11	12	13
Half	8	7	1	2	2	0	2	2	3	5

Treatment	Total	Mean	Sum of squares
Whole	87	10.875	42.875
Half	17	2.125	14.875

Mean difference: 8.75 plants.
Significance of difference: Highly significant.

YIELD

Table 3 presents the yield of pods in grams from the different plots. It will be noticed in this table that the two high yields were obtained from the whole seeds in plots 1 and 7 and the three low ones, from the half in plots 7, 1 and 8. The third and fourth high yields, however, were obtained from the half and whole respectively in plot 3. The yield of the whole seed in the different plots was more uniform than that of the half seed as the range in the former was 414.8 to 651.0 grams and 233.3 to 528.2 grams in the latter. The total actual yields of the whole seed and half seed plants were 4.0275 kilos and 3.3312 kilos, equivalent to 2.69 tons and 2.22 tons computed yield per hectare respectively. Although the total yield of the whole was greater than that of the half, the difference between their means was not significant.

It may be mentioned in passing that the whole seed plants produced more immature and undeveloped pods than the half. While there was a significant difference in the number of immature pods between the two, there was no significant difference in the number of undeveloped pods.

TABLE 3.—*Yield of pods in grams from the different plots.*

Treatment	Number of replication	Degree of freedom	Weight in grams of pods from plots— 1	2	3	4	5	6	7	8
Whole	8	7	651.0	462.8	520.4	447.6	414.8	420.7	689.8	470.4
Half	8	7	352.6	420.6	528.2	407.5	510.0	507.3	233.3	371.7

Treatment	Total	Mean	Sum of squares
Whole	4,027.5	503.4375	61,219.96
Half	3,331.2	416.4000	69,214.00

Mean difference: 87.0375 grams.
Significance of difference: Insignificant.

The results of measurements of vines from the different plots are shown in Table 4. There was not much variation in the length of vines in the different plots. The longest vines were obtained from the whole in plot 3 and the shortest from the half in plot 7. The difference between the means was only 0.086 meter and was insignificant.

TABLE 4.—*Length of vines from different plots.*

Treatment	Number of replication	Degree of freedom	Length in meters of vines from plots — 1	2	3	4	5	6	7	8
Whole	8	7	1.11	1.15	1.25	1.12	1.09	1.07	0.95	1.00
Half	8	7	1.11	0.99	1.04	1.16	0.99	0.94	0.87	0.98

Treatment	Total	Mean	Sum of squares
Whole	8.74	1.0925	0.0586
Half	0.98	1.0100	0.0596

Mean difference: 0.0825 meter
Significance of difference: Insignificant.

Table 5 shows the weights of vines from the different plots. The difference between the mean weights of vines of the whole seed and the half seed plants was not significant.

TABLE 5.—*Weight of vines from different plots.*

Treatment	Number of replication	Degree of freedom	Weight in kilograms of vines from plots— 1	2	3	4	5	6	7	8
Whole	8	7	1.30	1.16	1.34	1.02	0.88	0.71	1.25	1.13
Half	8	7	0.83	1.14	0.91	1.15	0.95	0.94	0.75	1.20

Treatment	Total	Mean	Sum of squares
Whole	8.79	1.099	0.3315
Half	7.87	0.984	0.1856

Mean difference: 0.115 kilogram.
Significance of difference: Insignificant.

SUMMARY

1. When only one-half seeds were used for planting peanut a saving of about 47.16 per cent of the planting material is realized.

2. Both whole and half seeds germinated about the same time, the germination period being 4 to 5 days. There were more seeds that germinated from the whole seeds than from the half, the percentage germination being 98.75 and 87.07, respectively. The difference in number of seeds that germinated from both treatments was highly significant.

3. The plants from the whole seeds flowered earlier than the half, and on June 24, 1944 there were more plants flowering from the former than from the latter. The percentages of plants that had flowered from the whole and the half were 36.71 and 8.13, respectively. There was a highly significant difference between the mean numbers of flowering plants from the whole and half seeds.

4. No significant difference between the yields of the whole and the half seeds was obtained.

5. The weight and length of vines were not significantly affected by removing half of the seed before planting, although there was a difference in each case in favor of the whole seeds.

A METHOD OF PRE-DRYING AND FLUE-CURING VIRGINIA TOBACCO

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ONE TEXT FIGURE

As early as 1928 the Bureau of Plant Industry introduced Virginia tobacco for cultivation in the Philippines, but so far it has not been grown extensively. Owing to the limited culture of this tobacco in the past, no attempt was made to study in detail the flue-curing requirements, although curing trials had been attempted using more or less the method reportedly used in the United States. In anticipation of a large scale local production of Virginia tobacco, this study was made with a view to contributing some data for the development of a local method of flue-curing Virginia tobacco.

The method herein reported is the result of trials in the laboratory and involves two distinct phases, namely, (*a*) pre-drying treatment of leaves, that is, subjecting the tobacco leaves soon after poling to low temperature and high relative humidity in an etiolation chamber, and (*b*) drying the leaves with gradual increases in temperature to fix the desired yellow color. This study was conducted in the laboratory of the Tobacco Research Section, Bureau of Plant Industry, from December, 1943 to January, 1944. The method which was finally developed under laboratory conditions was later tried on a large scale with the use of the flue-curing barn (fig. 1) of the Bureau of Plant Industry, Manila, which was destroyed during the war. For the latter test, tobacco leaves of different Virginia tobacco grown in the Central Agricultural Experiment Station ground, San Andres, Malate, Manila, in the 1943–1944 tobacco season were used.

MATERIALS AND METHODS

1. *Source of leaves.*—Leaves of Gold Dollar tobacco grown in potted soil and fertilized with different kinds of composts were used for the laboratory study. The leaves were of different textures owing to the effect of fertilizers applied. For the large scale tests with the use of a flue-curing barn, leaves of different

Virginia tobacco varieties grown in the experimental plots of the Bureau of Plant Industry at San Andres, Malate, Manila, in 1943–1944 tobacco season were used.

2. *Harvesting and poling.*—A Virginia tobacco leaf is ready for immediate harvest when the margin and the tip turn yellow with a simultaneous appearance of small yellow patches on the lamina of the leaf. Only leaves at this stage of development were harvested, and subsequently poled and spaced two fingers apart in sticks or "palillos" one meter in length.

3. *Curing procedure: (a) Laboratory method—pre-drying.*—The fresh tobacco leaves in palillos were hung inside an improvised small etiolation chamber conveniently distanced (2 cm. apart) so that the air could circulate freely in between the leaves. Attempts were made to keep the temperature at from 24° to 27° C. and the relative humidity of the air in between 80 and 90 per cent in the etiolation chamber until at least one-half of the lamina of the tobacco leaves turned yellow. This period averaged 56 hours.

Drying.—The partly yellowed tobacco leaves in the etiolation chamber were removed from the palillos and then transferred into a Freas electric oven to dry. The oven was adjusted to different degrees of temperature keeping in it the materials at various lengths of time, as shown in Table 1.

TABLE 1.—*Showing duration of drying Gold Dollar tobacco leaves at different degrees of temperature in a Freas electric oven.*

Temperature	Duration of exposure	Remarks
°*C.*	*Hours*	
..	....	1st hour: Leaves flaccid but margin not dry.
30	10	10th hour: Only midrib green: lamina drying.
35	14	Lamina, ¼ dry.
40	14	Midrib, ¼ dry.
45	10	Lamina, dry: midrib, half dry.
50	8	Lamina, dry: midrib almost completely dry
60	8	Leaves dry
70	8	Leaves dry
75	6	Leaves dry
80	6	Leaves very dry
Total	84 (3½ days)	

(*b*) *Confirmatory test of the laboratory method by curing Virginia tobacco in flue-curing barn: First trial.*—Matured Virginia tobacco leaves of the varieties Cash, North Carolina Bright Yellow, White Stem Orinoco, Adcock, Eastern Carolina, Long Leaf Gooch, Gold Dollar, and Gold Leaf were gathered

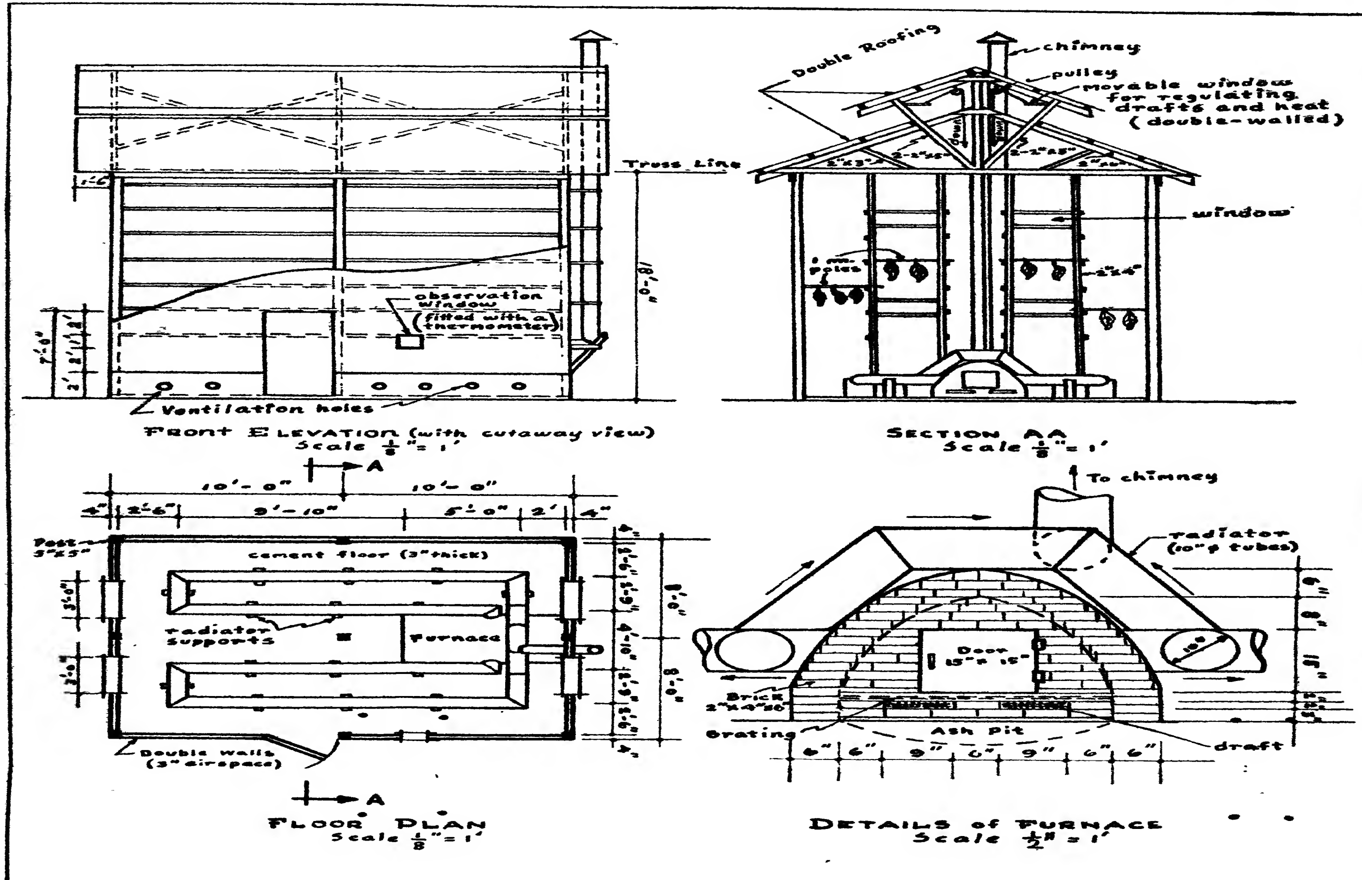

FIG. 1. Plan of a tobacco flue-curing barn.

from plants grown in the Central Agricultural Experiment Station, San Andres, Malate, Manila, on February 14, 1944. Immediately after harvest the leaves were poled and hung up in the flue-curing barn of the Bureau of Plant Industry (fig. 1), with the ventilators and door closed. An attempt was made to duplicate as nearly as possible the temperature and relative humidity obtaining under laboratory conditions in the flue-curing barn throughout the pre-drying period by sprinkling the ground floor of the barn with water whenever the relative humidity of the air inside was low. Records of observation are presented in Table 2, and the results of flue-curing are shown in Table 4.

TABLE 2.—*Showing readings of temperature and relative humidity of air in the flue-curing barn and the temperature of air outside flue-curing barn during the pre-drying periods.*

Date of observation	Pre-drying (in flue-curing barn)				Remarks
	Time of observation	Outside air temperature	Inside air temperature	Inside relative humidity	
		°C.	°C.	*Per cent*	
February 14, 1944	6 P.M.	30.0	29.5	70	Leaves turgid.
	8 A.M.	22.5	24.0	86	Leaves flaccid.
	10 A.M.	29.0	26.0	87	Cloudy
February 15, 1944	12 Noon	29.5	27.0	87	Very cloudy noon.
	6 P.M.	28.0	28.0	84	
	8 A.M.	23.3	26.0	79	
	10 A.M.	24.5	26.0	87	
February 16, 1944	12 Noon	28.5	27.5	87	
	2 P.M.	29.5	28.0	88	
	4 P.M.	29.5	28.0	88	
February 17, 1944	8 A.M.	([a])			Majority of leaves ready for drying.
	12 Noon		35.0		
	4 P.M.		39.0		Lamina drying.
February 18, 1944	8 P.M.		40.0		Do.
	10 P.M.		40.0		Do.
February 19, 1944	8 A.M.		49.0		Temperature raised to 60° C.
	4 P.M.		52.0		
	8 P.M.		61.0		
	12 P.M.		60.0		
February 20, 1944	2 A.M.		70.0		Temperature raised to 80° C
	4 A.M.		71.0		
	8 A.M.		79.0		
	12 Noon		80.0		
	8 P.M.		83.0		

Total drying period - 84 hours

[a] Heating and drying period started at 8 a. m., February 17, 1944.

Second trial.—Another set of Virginia tobacco leaves was harvested on February 25, 1944 from the same plants used in the first trial. At this time the fresh leaves, after they were poled were not hung in the flue-curing barn for pre-drying

treatment, but instead they were placed in a dugout, 3.75 meters long, 3.42 meters wide, and 1.53 meters deep. The top cover of the dugout was a layer of soil, 1½ feet thick. The dugout served as a good etiolation chamber because it had no other opening except a door and a ventilation window placed opposite the door which could be opened and closed at will. Without tobacco leaves inside the dugout, the temperature and relative humidity of the air were observed to vary from 24° to 27° C. and from 79 to 86 per cent, respectively, throughout the whole day. Those readings are within the range of the air condition used in the laboratory. The records of air condition in the dugout with tobacco leaves are presented in Table 3.

TABLE 3.—*Showing temperature and relative humidity of air in dugout and the response of leaves of different Virginia tobacco varieties to pre-drying treatment.*

[T, Turgid; F, Flaccid; YF, Started yellowing, leaves flaccid; YYF, Yellowing well advanced leaves flaccid. YYY, Lamina yellow, leaf ready for drying.]

Date	Time of observation	Outside air temperature [a]	Inside air temperature [b]	Relative humidity [c]	Response of Virginia tobacco varieties to pre-drying treatment: Cash	North Carolina Bright Yellow	White Stem Orinoco	Adcock	Eastern Carolina	Long Leaf Gooch	Gold Dollar	Gold Leaf
		°C.	°C.	*Per cent*								
Feb. 25, 1944	12 noon	30.0	26.0	84	Poled tobacco leaves hung up in the dug-out							
	1 P.M.	30.0	26.0	84	T	T	T	T	T	T	T	T
	2 do	31.0	26.0	86	T	T	T	T	T	T	T	T
	4 do	31.5	27.0	79	T	T	T	T	T	T	T	T
	5 do	31.5	27.0	79	T	T	T	T	T	T	T	T
Feb. 26, 1944	8 A.M.	23.0	24.0	91	T	T	T	T	T	T	T	T
	10 do	27.5	24.0	85	YF	F	F	F	F	F	YF	F
	11 do	28.9	25.0	86		F	F	F	F	F	...	F
	12 do	30.0	27.0	80	.	F	F	F	F	F	...	F
	2 P.M.	30.0	27.5	80	.	F	F	F	F	F	.	F
	4 do	30.0	27.5	79		F	F	F	F	F	..	F
	6 do	30.0	26.0	77		F	F	F	F	F		F
Feb. 27, 1944	9 A.M.	24.0	24.0	91	YYF	YF	YF	YF	YF	YF	YYF	YF
	11 do	27.5	25.0	86								
	5 P.M.		...		YYY		.	.		YY	YYY	YYF
					All tobacco leaves were placed in the flue-curing barn to dry at 5:00 P.M., Feb. 27, 1944; leaves flaccid.							
Total	56 hrs.	Av. 28.9	Av. 25.8	Av. 83.5	d	e	e	e	e	e	d	e

[a] Temperature of air under a shade outside of etiolation chamber (dugout).
[b] Temperature of air inside etiolation chamber (dugout).
[c] Relative humidity of air inside etiolation chamber (dugout).
[d] Ready for drying after 56 hours.
[e] Not ready for drying after the 56-hour period.

RESULTS

a. Laboratory method.—The Gold Dollar tobacco leaves used in this study as described under laboratory method turned from green to yellow color to a point ready for drying at the end of the 56th hour in the pre-drying chamber. The leaves remained in flaccid condition and no drying along the margins and tips was observed. The drying of the leaves was completed after a period of 84 hours in the Freas electric oven and all of them cured yellow with good aroma.

b. Confirmatory test of laboratory method.—The drying of the leaves in the confirmatory test was carried out in the same flue-curing barn used in the first trial, and the duration and intensity of heat applied were made to be almost the same as those employed in the first trial. The results of flue-cured tobacco leaves (in the flue-curing barn) are shown in Table 4.

TABLE 4.—*Showing results of flue curing with the use of flue-curing barn and percentage of leaves cured yellow of different Virginia tobacco leaves.*

Variety	First trial—			Second trial—			Remarks
	Total No. of leaves	No. of leaves cured yellow	Per cent cured yellow	Total No. of leaves	No. of leaves cured yellow	Per cent cured yellow	
Cash	255	203	86	165	165	94	Bright yellow.
North Carolina Bright Yellow	145	66	45	196	82	42	Yellowish green.
White Stem Orinoco	93	54	58	146	91	62	Dull yellow.
Adcock	144	82	47	207	120	58	Do.
Eastern Carolina	132	83	62	292	195	66	Pale yellow.
Long Leaf Gooch	106	70	66	137	87	63	Do.
Gold Dollar	124	107	86	183	161	91	Bright yellow.
Gold Leaf	111	71	63.	204	133	65	Pale yellow.

DISCUSSION OF RESULTS

Nature of curing process.—Tobacco curing is essentially the subjecting of the living cells of the tobacco leaves to a gradual starvation in the absence of sunlight; and while the cells are starving for lack of food and water in the curing chamber, the chlorophyll, because of the absence of sunlight, is transformed into yellow pigment. The yellowing of the leaf is the first stage of color-change in curing leaf tobacco. This process takes place before the death of the cells. Paguirigan et al.(1) state that:

> It is not uncommon to find leaves that are spotted green in the curing house nor is it infrequent to find some cured leaves of commerce with

green spots on them. This is due to the fact that when tobacco leaves are harvested, especially by the priming method, they are piled and left in the field, exposed to strong sunlight for some time. Under this condition, no doubt, many of the leaves are killed by desiccation either in part or in isolated spots rather than by a slow process of starvation which takes place in the curing process. The prematurely killed portions of the leaf remain green and do not change color in the curing house.

It is evident from the foregoing statement that the first color-change, green to yellow, is a life process and, according to Loew,(2) immediately after death of the cells of the leaf, browning of the yellow leaf sets in. He explains that "the oxidases are contained in the plasmatic living part of the cell and not in the cell sap so that when the cells die the permeability of the plasmatic membrane is increased. The oxidase and the oxidazable matter of the cell sap mix intimately and browning of the yellow leaf sets in." This is the reason why Virginia tobacco is subjected to high temperature when the color of the leaves is already yellow, but, of course, the heating must be gradual, in order not to cause too rapid dehydration. The removal of water from the cells should be gradual in order to give sufficient time for the conversion of the green pigment of the leaf to yellow.

The yellow leaves are therefore subjected to gradual drying up to 80 degrees centigrade to fix the yellow color. For satisfactory results, therefore, curing should be done on the basis of the above two fundamental principles, that is, first, by placing the leaves in an etiolation chamber where the atmospheric conditions could be controlled to prevent rapid transpiration, thus subjecting the leaves to gradual dehydration of the cells and at the same time affording sufficient time for the conversion of the green pigment of the leaf to yellow pigments; and, second, the proper fixing of the yellow color.

Color and quality of cured tobacco leaves—laboratory method.—As described under laboratory method Gold Dollar tobacco leaves placed in a pre-drying chamber for etiolation were found ready for drying at the end of the 56th hour. The leaves remained flaccid. There was neither curling of the lamina nor drying of the tips of the leaves, indicating the suitability of the air condition in the pre-drying chamber. The rise of the air temperature in the Freas electric oven, as shown in Table 1, was made gradual, starting from 30°C. to as high as 80°C. It took 84 hours to finish the drying process. The leaves so treated all cured yellow. They possessed the golden

yellow color and the typical Virginia tobacco aroma, and although the tobacco leaves were not aged, cigarettes were prepared from them after three weeks but under normal condition, the leaves should be aged for not less than 2 years. As the true smoking quality of a cigarrette cannot be determined to the exclusion of the personal element involved, it was deemed wise to distribute them among officials of various offices of the Bureau of Plant Industry for trial and for comment. Surprisingly enough the remarks in general were to the effect that the quality of the cigarrettes was more or less similar to that of the imported brands at that time.

Confirmatory test of laboratory results.—As shown in Tables 2 and 3, the air conditions in the etiolation chambers were not far from those observed under laboratory conditions. Also, the temperature of the air in the flue-curing barn during the drying period was within the range of heat intensity used in the Freas electric oven. Incidentally, it is gratifying to report that the flue-curing barn yielded very satisfactory result. This type of flue-curing barn, therefore, is recommended for a wider and more extensive use.

Table 4 shows the variety names of Virginia tobacco used for testing the laboratory method of flue-curing. It combines the results of two trials using in both instances the same flue-curing barn and leaves from the same plants, and simulating as nearly as possible the air condition observed in the laboratory methods. The data obtained, as shown in Table 4, show that leaves of varieties Cash and Gold Dollar both cured 86 per cent yellow in the first trial, and 94 per cent and 91 per cent, respectively, in the second. The leaves of the six other varieties cured yellow between 42 and 66 per cent. In both trials, leaves of North Carolina Bright Yellow cured yellow the poorest, 45 per cent in the first trial and 42 per cent in the second, confirming the suspicion that it was not a pure Virginia. Why is it that the Virginia tobacco leaves cured in the flue-curing barn did not all turn yellow, since under laboratory conditions the Gold Dollar tobacco leaves studied all cured yellow? This is presumed to be due to two causes: first, age of the leaves at harvest time, and, second, varietal difference. It was noted in the pre-drying treatment as confirmed later, that tobacco leaves harvested young took a longer time to change color, from green to yellow, in the pre-drying chamber than those which were quite mature. If one were to wait until the color-change

of those young leaves had reached a point when they were ready to be transferred to the flue-curing barn to dry, the older leaves which had been ready for drying when the young ones were still green, would have passed the yellow stage and would have reached the browning phase. Under this condition the old leaves would cure brown instead of yellow. It was, therefore, found necessary, because of limited facilities, to transfer the still green tobacco leaves (the young ones) into the flue-curing barn to dry, together with the yellowed leaves. The cells of the young leaves were killed in the flue-curing barn prematurely and the green pigment remained unchanged, thus remaining green.

The problem of flue-curing Virginia tobacco leaves depends to a large extent upon the variety and leaf texture. As shown in Table 3, leaves of some Virginia tobacco varieties did not change readily in color, that is from green to yellow in the etiolation chamber. Cash and Gold Dollar tobacco leaves started yellowing at the end of the 23rd hour; the yellowing of leaves was well advanced after the 45th hour and the leaves were ready for drying at the 56th hour. The leaves of the six other varieties, namely, North Carolina Bright Yellow, White Stem Orinoco, Adcock, Eastern Carolina, Long Leaf Gooch and Gold Leaf started yellowing at the end of the 45th hour in the etiolation chamber and yellowing of leaves was well advanced at the 56th hour. Because there was only one flue-curing barn available the leaves had to be put in the flue-curing barn together with the Cash and Gold Dollar tobacco varieties although they were not yet ready for drying. The temperature in the flue-curing barn was then gradually raised from 30° to 80°C. Those leaves which did not change color from green to yellow in the etiolation chamber were dried prematurely and cured green resulting in a poor quality of tobacco. It is believed, however, that had the green leaves been kept longer in the etiolation chamber until they were finally ready for drying, a higher percentage of cured yellow leaves would have been obtained from the six varieties mentioned above. On the basis of this finding especially if there is only one flue-curing barn to operate on the farm, the farmer should resort to the growing of either the Cash or the Gold Dollar variety.

SUMMARY

1. A laboratory method of pre-drying and curing Virginia tobacco has been described and tested with the use of a flue-

curing barn. Leaves of Cash and Gold Dollar tobacco varieties cured yellow, as high as 94 and 91 per cent, respectively.

2. The type of flue-curing barn constructed by the Bureau of Plant Industry is easy to operate. It works very well and is recommended for a wider use.

3. A relatively good-sized dugout, with a layer of soil 1½ feet thick as cover, has been found to meet the need for an etiolation chamber.[1] The relative humidity and temperature of the air existing in the dugout come within the range of air temperature and humidity requirements demanded during pre-drying period.

4. The varieties Cash and Gold Dollar tobacco responded adequately to the treatment. Both cured better than North Carolina Bright Yellow, White Stem Orinoco, Adcock, Eastern Carolina, Long Leaf Gooch or Gold Leaf. Where there is only one flue-curing barn, a farmer should grow only one variety of Virginia tobacco. However, Cash and Gold Dollar varieties could be grown together for they were found to have the same flue-curing requirements.

LITERATURE CITED

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2. LEOW, O. Physiological studies of Connecticut leaf tobacco. U. S. Dept. of Agr. Report No. 65 (1900).

[1] The chamber must be provided with a good system of ventilation which could be made to close or open readily at will.

ILLUSTRATION

TEXT FIGURE

Fig. 1. Plan of a tobacco flue-curing barn.

THE LEAF-GALL DISEASE OF RICE AND CORN IN THE PHILIPPINES

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TWO PLATES

The present paper reports the results of our studies on the leaf-gall disease of rice and corn from 1940 to 1941, and from 1945 to 1946. This disease of graminicolous species, in so far as the writers are aware, has not been previously studied in the Philippines. In 1924 Ocfemia(6) reported a gall disease of corn but no attempt was made to study its etiology.

THE DISEASE

HOST RANGE DISTRIBUTION AND ECONOMIC IMPORTANCE

The leaf-gall disease of rice and corn was first noted on Apostol variety of rice at Sitio Lauan, San Juan de Mata, Tarlac, in October, 1940. In the same year a similar disease was found infecting the native corn varieties Lagkitan and White Flint in the vicinity of Maligaya Rice Experiment Station, Nueva Ecija, and the sweet corn variety Delicious Burpee at the Central Experiment Station, Manila.

Subsequent field surveys revealed that the malady attacked also in varying degrees of severity the rice varieties Apostol, Binondoc in Tarlac Province; the varieties Macan Bino, Ketan Koetoek, Milagrosa in Buenavista Estate, Bulacan; and the varieties Raminad Str. 3, Elon-elon, Apostol, Kinandang Pula, Dumali, Binondoc and Piling Baybay in Nueva Ecija. In addition, the disease was noted on the varieties Guinangang, Carreon, Caawa II, on different hybrids between Milagrosa and Ketan Koetoek and different strains of Seraup Ketchil in the Central Experiment Station, Manila, and on two sets of unidentified rice varieties received from the Provinces of Iloilo and Cebu, respectively.

It seems that the disease is more destructive to corn than to rice. It was found affecting corn in Manila, and in the Provinces of Batangas, Cebu, Laguna, Zamboanga, Cotabato, Bukidnon, Misamis Oriental and in Bauang, La Union, where at one time it caused an estimated loss of about 25 per cent

on Lagkitan variety. In Tarlac the loss caused by the disease on the same variety of corn was about 20 per cent.

SYMPTOMS OF THE DISEASE

Diseased plants are generally stunted and they produce leaves that are deeper green than the normal (Plate 1). Narrow elongated galls appear on the nether surface of the leaves and on the leafsheath. In artificially inoculated plants these galls start as small white, hardly discernible specks on the lower surface (Plate 2, figs. *a* and *b*). They gradually elongate following the veins and form a string of separate spindle-shaped swellings (Plate 1, and Plate 2, figs. *a* and *b*). They vary in size from a speck to several millimeters long. With age, galls on the same line may coalesce end to end and form a continuous rough corky surface (Plate 1, and Plate 2, figs. *a* and *b*). As the galls develop on the veins those that appear on the leaves run parallel to the midrib. In many respects the production of the galls and the effect on the growth of corn and rice plants by the gall disease are similar to those caused by the Fiji disease on sugar cane.

Microscopic examination of cross sections [1] of the galls showed that the swelling is caused mainly by the proliferation of the phloem cells, the bundle sheath and other cells surrounding the xylem vessel. Evidently there is an increase in the number and in the size of the phloem cells.

Severely infected rice plants produce stunted culms which produce small abortive panicles. Leaves of badly affected corn plants show a tendency to twist in various ways or roll inward (Plate 1 and Plate 2, figs. *a* and *b*). As a rule diseased corn plants produce small abnormal ears with poorly developed kernels.

ETIOLOGY OR CAUSE OF THE DISEASE

MATERIALS AND METHODS

As the symptoms of the disease on rice and corn are highly suggestive of a virus infection, studies in this direction were conducted. Affected rice and corn plants were collected from Tarlac and Nueva Ecija and were grown separately in Manila inside insect-proof wire cages. Later, individuals of the rice leaf hopper, *Cicadula* sp. (Plate 2, figs. *c*, *d*, and *e*) from the cultures were allowed to feed on these diseased plants at different lengths of time for use in transmission experiments.

[1] The prepared microphotographs of infected and healthy leaves of rice and corn were burned during the battle of liberation.

The cultures of *Cicadula* were prepared by collecting healthy individuals and allowing them to breed on healthy rice, corn, and sorghum (*Sorghum vulgare* L.) seedlings which were grown inside insect-proof wire cages. These cultures were placed under observation for sometime. As no leaf-gall infection on any of the plants was noted even after a few months, these cultures were regarded healthy and they were used as the sources of all insects employed in transmission work.

The experimental plants used in the experiments were likewise grown inside insect-proof wire cages. Each plant was inoculated by transferring to it individuals of *Cicadula* from diseased or viruliferous cultures. The control or check plants received transfer of individuals of *Cicadula* from the healthy or nonviruliferous cultures.

TRANSMISSION BY INSECTS

Following the method described above and with diseased rice as a source of inoculum, 17 transmission experiments involving 43 rice seedlings and 68 corn seedlings were performed from 1941 to 1946. Nineteen parallel experiments with the use of infected corn as a source of the disease were performed during the same period on 50 rice seedlings and 42 corn seedlings, respectively. All together, besides the controls, 36 transmission experiments were conducted involving a total of 93 rice seedlings and a total of 110 corn seedlings. The results obtained in these experiments may be seen in Table 1.

TABLE 1.—*Showing the transmission of the gall disease of rice and corn by the leaf hopper Cicadula.*

Date inoculated.	Source of virus.	Length of feeding on sources of virus.	Plants inoculated.	No. of plants inoculated.	No. of insect per plant.	No. of plants infected.	Incubation period.	Remarks.[a]
		Hrs.	RICE:				*Days*	
1941 ...	Rice	24-72	Apostol ..	10	1	7	12-20	Moderate.
			Macan Bino .. .	10	1	6	12-20	Do.
			CORN:					
		24-72	Lagkitan	10	1	8	10-15	Severe.
			Delicious Burpee	12	1	10	10-15	Do.
			White Flint	5	1	4	12-18	Moderate.
			Yellow Flint	5	1	3	12-18	Do.

[a] Three degrees of infection were arbitrarily distinguished as follows:
SLIGHT: A few galls per plant. MODERATE: Several to many galls per plant. SEVERE: Large continuous galls causing leaves to twist in various parts or roll inward.

TABLE 1.—*Showing the transmission of the gall disease of rice and corn by the leaf hopper Cicadula*—Continued

Date inoculated.	Source of virus.	Length of feeding on sources of virus.	Plants inoculated.	No. of plants inoculated.	No. of insect per plant.	No. of plants infected.	Incubation period.	Remarks.[a]
			RICE:					
1941	Corn	48–72	Apostol	6	1	5	15–20	Moderate.
			Macan Bino	5	1	3	15–21	Do.
			Caawa II	5	1	5	14–19	Do.
			CORN:					
1941	Corn	48–72	Lagkitan	5	1	5	10–14	Severe.
			Delicious Burpee	5	1	5	8–15	Do.
			White Flint	4	1	4	11–19	Moderate
			Yellow Flint	4	1	4	12–18	Do.
			RICE:					
1941	Control		Caawa II	10	1	...	...	All healthy.
			Macan Bino	10	1	...	...	Do.
			CORN:					
	Control		Lagkitan	5	1	...	...	All healthy.
			RICE:					
1945	Rice	48	Guinangang	4	1	3	14–19	Moderate.
			Apostol	3	1	2	13–20	Do.
			Khao-Bai-Sri	3	1	3	13–20	Do.
			Carreon	3	1	3	14–18	Do.
		72	Raminad Str. 3	3	1	2	14–22	Slight.
			Macan Tago	4	1	2	12–23	Do.
			Elon-elon	3	1	2	18–21	Do.
			CORN					
1945	Corn	48	Lagkitan	5	1	5	8–12	Severe.
			White Flint	4	1	3	12–17	Moderate
			Yellow Flint	3	1	3	8–12	Do.
		72	Lagkitan	5	1	4	10–16	Severe.
			White Flint	4	1	3	12–17	Moderate.
			Yellow Flint	3	1	3	10–12	Do.
			RICE:					
1945	Control		Carreon	12	1	...	...	All healthy.
			CORN:					
	Control		Lagkitan	12	1	...	...	All healthy.
			CORN:					
1946	Rice	48	Lagkitan	8	1	6	10–12	Severe.
		72	Do	10	1	7	8–12	Do.
			White Flint	8	1	5	9–12	Moderate.
			Yellow Flint	10	1	7	10–14	Do.
			RICE:					
1946	Corn	48–72	Carreon	5	1	5	12–16	Moderate.
			Apostol	5	1	5	15–20	Do.
			Khao-Bai-Sri	5	1	8	15–22	Slight.
			Guinangang	8	1	6	15–19	Do.
			Macan Tago	6	1	4	15–20	Do.
			Elon-elon	5	1	8	16–22	Do.

[a] Three degrees of infection were arbitrarily distinguished as follows:
SLIGHT: A few galls per plant. MODERATE: Several to many galls per plant. SEVERE: Large continuous galls causing leaves to twist in various parts or roll inward.

MECHANICAL TRANSMISSION

Following methods similar to those previously described by other investigators,(2, 3, 5) attempts were made to transmit the disease by manual means.

By sap injection.—Leaves of diseased rice, variety Apostol, were crushed in a porcelain mortar containing about 15 cc. of sterile water. The sap obtained was filtered and the filtrate was injected by means of a syringe into 5 healthy rice seedlings of the Apostol variety and 5 corn seedlings of the variety Lagkitan. Check plants inoculated with sap from healthy rice and corn plants were provided. Both the inoculated and the control plants were kept separately inside insect-proof wire cages for observation.

It was noted that none of the inoculated rice and corn seedlings showed leaf-gall infection. Subsequent experiments with the use of the expressed sap from a diseased corn were performed but in all of these trials the result obtained were likewise negative.

By needle-pricks.—With a fine needle No. 00 and following the method described by Sein(9) for sugar cane mosaic, 6 healthy seedlings each of rice (Macan Bino) and corn (Lagkitan) were inoculated. In this test none of the treated plants showed infection after allowing sufficient time for observation.

Through-bruises.—Leaves of healthy rice and corn seedlings were slightly bruised by means of glass wools. The bruised areas were then rubbed with a wad of cotton previously soaked in expressed sap of diseased plant. Out of 6 rice (Apostol) and 6 corn (Lagkitan) seedlings treated none showed infection with the disease even after several weeks.

Through insect exuviae and excreta.—Exuviae and excreta of viruliferous hoppers were crushed in test tubes containing about 15 cc. of distilled water. After filtering, the clear filtrate obtained was used as a source of inoculum in transmission experiments. Of the 12 seedlings each of rice (Apostol) and corn (Lagkitan) injected with the filtrate with the use of syringe none showed infection with the leaf-gall disease.

THE PHYSIOLOGY OF TRANSMISSION

Minimum period for acquiring the virus.—With adult individuals of *Cicadula* sp. allowed to feed on the source of virus

for different lengths of time: 1 hour,[2] 2 hours, 5 hours, 10 hours and 20 hours, different sets of experiments were performed using young corn and rice seedlings grown in insect-proof wire cages. Twenty seedlings with an equal number of individual hoppers were used.

In these tests it was noted that infection was obtained after 15 to 20 days on the seedlings fed upon by insects previously allowed to stay on the source of virus for 10 hours, 20 hours, and 25 to 30 days for those that fed 2 hours and 5 hours on the source of virus.

Minimum period of transmitting the virus.—Viruliferous hoppers were transferred to experimental corn and rice seedlings and were allowed to remain on these plants at varying lengths of time as 1 hour, 2 hours, 5 hours, 10 hours, and 20 hours. These experiments involved 20 seedlings, each of which was supplied with one leaf hopper.

In these experiments most of the inoculated plants in the different sets showed signs of infection in 18 to 20 days.

Retention of the virus by the vector.—A series of inoculation experiments with the use of 5 corn and 5 rice seedlings and the same number of leaf hoppers showed that a viruliferous leaf hopper can infect plants successively by allowing it to feed for a limited time on each plant in the series. These results tend to show that the insect retains the leaf-gall virus once it has acquired it from a diseased plant. Evidently this is a characteristic of plant viruses that are biologically transmitted.

TRANSMISSION THROUGH SEEDS

Seeds obtained from previously inoculated rice and corn were planted separately in pots inside wire cages. Four sets of experiments were performed involving 20 rice seedlings and 20 corn seedlings. In these tests none of the seedlings of either rice or corn grown from seeds of infected plants showed leaf-gall infection.

Transmission of virus through the seeds seldom occur in plants. Even the virus of the well-known infectious tobacco mosaic does not appear on seedlings grown from seeds produced by mosaicked plants.(4)

DISCUSSION OF RESULTS

It may be noted in Table 1 that the leaf-gall disease of rice readily infected rice and corn seedlings. Similarly, the gall

[2] Some difficulties were encountered as some newly transferred leaf hoppers in confinement do not readily settle or feed on the host plant.

disease virus of corn was easily communicated to both rice and corn seedlings by individuals of the leaf hopper *Cicadula* sp. The results definitely established the virus nature of the gall disease. It is significant to note that the symptoms produced on rice and corn seedlings by the rice-gall disease are hardly distinguishable from the symptoms caused by the gall disease of corn on the same plants. Presumably, the gall disease of rice and corn are caused by the same or very closely related strain of virus.

The failure to transmit the virus by mechanical means places the gall disease of rice and corn in the same category as the Fiji disease of sugar cane,(8) stunt disease of rice,(1) bunchy-top of abaca,(7) aster yellows,(5) and other virus troubles that are known to be transmitted only by specific insect vectors.

The ease with which individuals of *Cicadula* could get the virus from diseased rice and corn plants may account for the occasional occurrence of the disease in a severe form. Probably *Cicadula* is a natural carrier of the leaf-gall virus of rice and corn in the field.

SUMMARY

1. The leaf-gall disease of rice and corn is hitherto unreported in the Philippines.

2. It is characterized by the stunted growth of the affected plants and by the production of elongated spindle-shaped galls on the lower surface of the leaves and on the leafsheath.

3. The disease causes the production of abortive panicles in rice and small undersized ears with poorly developed kernels in corn.

4. It is caused by a virus which could be communicated by individuals of *Cicadula* from diseased rice to corn and from infected corn to rice in a short time.

5. The incidence of the disease in the field may be minimized by immediate eradication or destruction of diseased plants, control of the insect vector, and by developing resistant varieties of rice and corn.

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The authors gratefully acknowledge the helpful suggestions extended to them by Dr. F. M. Clara, chief, Plant Pathology Section, and by Dr. G. Merino and Mr. F. Q. Otanes, chief and assistant chief, respectively, Plant Pest and Disease Control Division, for identifying the leaf hopper used in the transmission experiments.

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ILLUSTRATIONS

PLATE 1

A color drawing of an infected Lagkitan corn; natural size. Note the characteristic deep green color of the foliage. The galls are conspicuously large and continuously forming rough and corky surface. Note the tendency of the infected leaves to roll inward.

PLATE 2

FIG. *a.* A sketch of an inoculated young rice plant, Apostol variety, about 1½ months old; natural size. Note the formation of galls on the nether surface of the leaf and leafsheaths. They vary in size from a mere speck to several millimeters long. With age they coalesce end to end and form a continuous rough corky surface.

b. A sketch of an inoculated young corn plant, Lagkitan variety, about 1 month old; natural size. Note the characteristic galls on the nether surface of the leaves and leafsheath ranging in size from a mere speck to several centimeters long. The leaf with several adjacent continuous galls shows a tendency to roll inward.

c. A sketch of an adult of the vector, *Cicadula* sp.; $\times$ 20.

d. A ventral view of an abdomen of the male adult; $\times$ 20.

e. A ventral view of an abdomen of the female adult; $\times$ 20.

PLATE 1

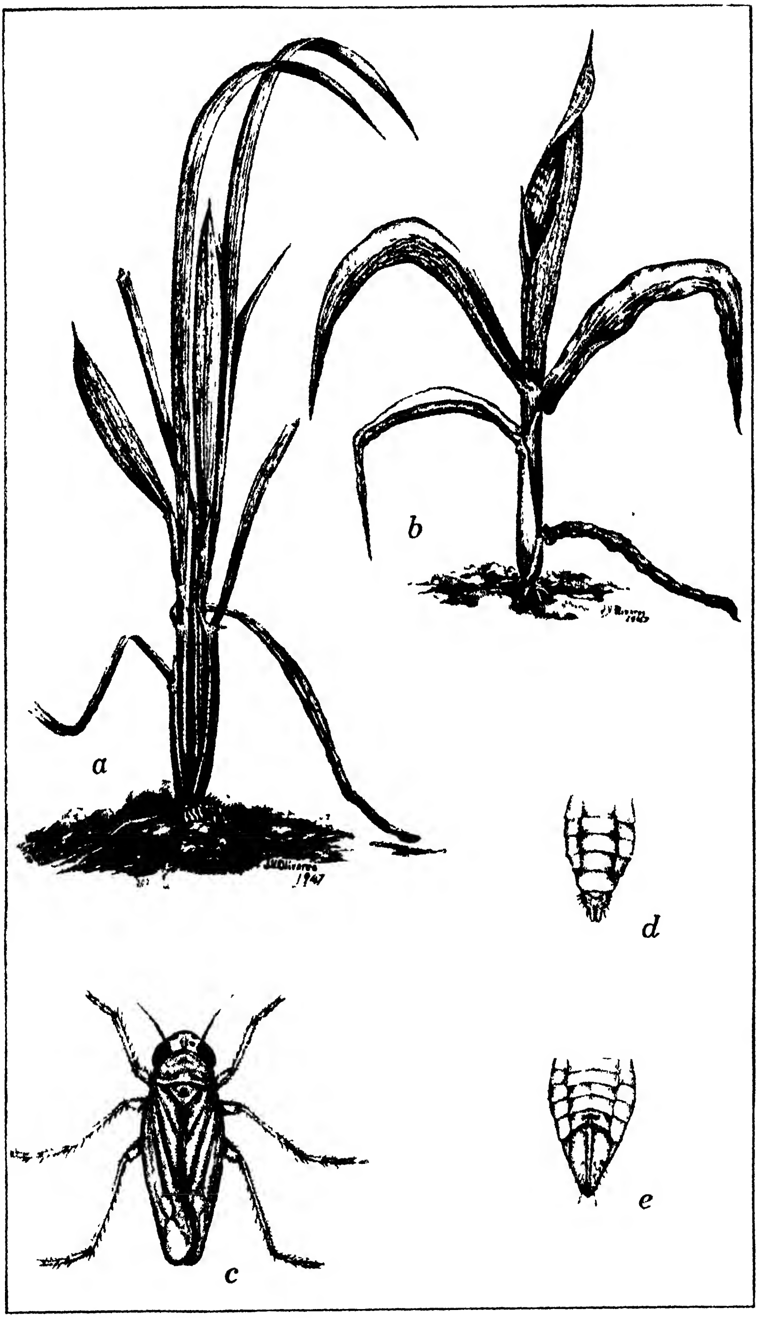

PLATE 2.

RICE CULTURE IN TAIWAN [1]

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NINE TEXT FIGURES

INTRODUCTION

Object.—It is well known that Taiwan is not only self-sufficient in rice but is an exporter of large quantities of this cereal. She exports more than 50 per cent of what it produces, to Japan, and this in spite of the fact that compared in area with the Philippines for example, she has a relatively larger population to support. In 1940 Taiwan produced 38,823,284 cavans of palay rice from an area of 626,182 hectares equivalent to an average yield of 52 cavans per hectare. In the same year, the Philippines produced 53,698,780 cavans of palay from 2,080,380 hectares (Statistics Division, Department of Agriculture and Commerce) equivalent to 25.80 cavans per hectare. Since the population of Taiwan is about 6,000,000 while that of the Philippines is about 18,000,000 (1941), or a ratio of 1 to 3, the Philippines should be producing about 3 times the rice Taiwan produces, that is about 65,892,528 cavans instead of only 53,698,780 cavans. This enviable position of the Taiwan rice industry had been reported to be due to the improvements which had been made in the various phases of rice culture and rice industry, mainly as a result of agricultural research.

It was the object of this study to determine the methods of culture used, particularly what characteristics or features of the Taiwan rice culture had been responsible for the phenomenal progress it had made, and which of these methods could be adopted and could be introduced, immediately if possible, into the Philippine rice farming, in order to increase production and yield.

The area of Taiwan is 3,710,000 hectares. Of this area, 880,000 hectares are under cultivation of which 626,182 hectares are devoted to rice in 1940. Of the rice area, 496,640 hectares are irrigated. Of the total cultivated land, 540,000 hectares are wet and 340,000 hectares dry land.

[1] A part of a report embodying the results of studies and observations made by the author in Taiwan as a member of the Philippine Agricultural Survey Commission, during September, October and November, 1944.

Time and places covered.—While information was secured on rice culture in all the five provinces and two districts of Taiwan, only in the five provinces was actual observation made. The study lasted 53 days, beginning September 20, 1944, the day after the Commission landed on Taiwan, to November 11, 1944. Of these days, 40 were spent in Taihoku Province, 1 in Shinchiku, 4 in Taichu, 5 in Tainan, and 3 in Takao. The observation covered not only rice fields but also farm operations being conducted in villages, towns, and cities such as compost making, rice-straw weaving and rope making, drying of green manure seeds, milling, warehousing and "sake" making and "tausi," "toyo" and "mizo" manufacture. The party visited and studied all the important types of irrigation systems of the Island from the largest and most costly to the simplest and least expensive. A part of the wind-swept region which is being reclaimed by combined establishment of effective windbreaks and irrigation systems for rice and sugar cane was also visited.

Sources of information.—The most important sources of information which supplements that obtained by the writer from his visual study of rice fields and cultural operations are the many government officials representing the different agricultural branches of the Taiwan Government, Officials of the Government General, of the province, municipalities and villages, who had been assigned to give conferences and assist the Commission in various capacities and who are too many to be named here. In the case of the rice study of the writer, special acknowledgment should be made to Dr. Eikichi Iso, Director of the Government Agricultural Research Institute, and his assistants, particularly Mr. Susuki, assistant in rice work, including the personnel of the Faculty of Agriculture of the Taihoku Imperial University, of five branch Experiment Stations of the Research Institute, of the Provincial Experiment Stations and of the Government Sugar Experiment Station and of the Cotton Research Institute. All accessible literature was availed of and publications referred to are listed in the end of this report.

It should be mentioned here that practically this entire report, especially the essential parts, was kindly gone over by Doctor Iso for corrections and suggestions before it was put in final form.

Importance of Taiwan rice industry.—Rice is the most important crop of Taiwan. The total area of the Island is

3,710,000 hectares. Of this area, 872,000 hectares were agricultural land. Of this agricultural area, rice occupied in 1936, 533,829 hectares or 61 per cent of the agricultural area. Actually, however, because of two-crop system of planting rice on a large area, the rice harvest of 1936 represented a combined total of 702,682 hectares.

Of 652,000 hectares cultivated in 1939, rice occupied 621,016 hectares. Table 1 shows the area devoted to rice in 1940 compared with the area devoted to other crops.

TABLE 1.—*Comparative approximate hectarage of Taiwan crops in 1939.*

	Hectares
Rice	645,000
Sugar cane	152,000
Sweet potato	146,000
Tea	43,000
Vegetable	41,000

The 1940 rice hectarage was divided among provinces, as shown in Table 2.

TABLE 2.—*Hectarage and production of rice in different provinces and districts of Taiwan in 1940. (Data furnished by Prof. Jose Velmonte of the Commission).*

Province	Area Ko.[a]	Production Koku[b]
Taihoku	99,835.04	1,270,048
Shinchiku	144,026.99	1,960,242
Taichu	157,128.47	2,606,369
Tainan	126,393.91	1,729,978
Takao	87,351.17	1,278,810
Taito	12,792.63	131,275
Karenko	18,020.57	179,608
Total	645,548.78	9,151,740
Average yield	Per Ko.[c]	14.1 Koku[d]

[a] 1 Ko.=0.97 Ha. approximately.
[b] 1 Koku=2.4 cavans.
[c] Irrigated portion was=469,000 Ha. (according to Mr. Graciano Militante of the Commission.)
[d] 14.1 Koku=62 cavans, assuming that 91 per cent of the reported production was Horai and 9 per cent native rice, according to the following computation. Assume also that the production reported is hulled rice:

91% of 14.1=12.8 Koku Horai
9% of 14.1=1.3 Koku Native
12.8 Koku hulled Horai = 1,830.4 Kg. = 2,402 Kg. palay
1.3 Koku Native=180.7 Kg.=243 Kg. palay
Total--2,645 Kg.
2,645 Kg. palay=60.11 cav. per Ko.

$$=\frac{60.11}{0.97}=62 \text{ cavans per Ha.}$$

CLIMATE OF TAIWAN IN GENERAL

TABLE 3.—*Meteorological data of the regions observed.*

Stations	Situation		Height barometer above sea level	Air pressure		
	Long. E	Lat. N		Mean	Maximum	Minimum
			meters.		*mm.*	
Taihoku (Tayseh)	121°30′	25°02′	9.3	760.4	775.8	744.6
Taichu (Taichung)	120°42′	24°09′	72.0	759.2	772.4	741.4
Tainan	120°12′	22°59′	14.3	759.2	772.6	739.4
Taito (Taitung)	121°8′	22°45′	9.9	760.1	773.7	740.6
Koshun	120°4′	22°01′	20.5	759.3	771.6	727.0
Hokoto (Pescadores)	119°24′	23°33′	11.0	759.7	773.3	731.9
Sharioto (Palm Island)	121°45′	25°09′	4.5	760.9	775.7	774.1

Air temperature			Number of days with						
Mean	Maximum	Minimum	Rain, snow and hail	Thunder	Fog	Frost	Clear	Cloudy	Storm
Month °C	Month °C	Month °C							
21.3 VII	35.3 V	6.8 II	174	32	3		11	165	134
21.5 VI	33.6 VIII	4.3 II	111	31	4		68	89	43
22.6 VI	33.6 VIII	7.2 XII	110	50	12		61	71	51
22.8 VI	33 4 IX	11.0 II	154	25			15	178	112
23.9 VI.	33.2 V	10.0 I	147	13			32	109	121
22.1 VI	31.5 VI	11.9 I	90	21	2		41	132	257
21.1 VII	33 3 VIII	7.6 I	234	28	3		30	207	87

Velocity of wind				Mean relative humidity	Precipitation. Total
Mean (Miles)	Maximum				
	Miles	Days.	Month		
				Per cent	*mm.*
5.1	19.0	27	VI	81	1,733 8
2.9	16.2	29	VI	82	1,804.9
4.4	21.1	27	VI	70	1,882.8
5.1	21.5	27	VI	80	1,889 1
5.8	40.3	27	VI	80	2,106 9
10.0	39.2	27	VI	80	1,329.1
5.0	26 9	26	VII	86	3,012.0

Climate of Taiwan from the standpoint of rice culture.—The Tropic of Cancer passes a little bit below the City of Kagi. Tainan Province, and a bit below a line that would divide the Island from east to west in the middle. For this reason, the southern part of the Island is more tropical than the northern part, which is subtropical. The vegetation of Taiwan is observed to be more and more like that of the Philippines as one goes from north to south.

According to Prof. T. Tanaka, of the Taihoku Imperial University, 56 per cent of the area of Taiwan has a tropical

climate, 31 per cent subtropical, 11 per cent temperate and 2 per cent alpine. For this reason, one finds rice varieties which are adapted to temperate, others to subtemperate and still others to tropical conditions.

The increase in temperature which one finds as he goes from north to south is illustrated in the mean temperature in the following places arranged from north to south, from Taihoku, which is almost at the extreme north, to Koshun almost in the extreme south.

Mean air temperature in °C.—Taihoku, 21.3; Taichu, 21.5; Tainan, 22.6; Taito, 22.6; Koshun, 23.9. The absolute minimum temperature is 0.2°C. in north and 9.5°C. in south while the average minimum temperature is 12.1°C.

From the standpoint of rainfall, the seasons of Taiwan are classified into rainy and dry seasons. The rainy season in the northern part occurs during October to March, while in the southern part, during May to September. Therefore the rainy season in the southern part almost coincides with that of the western part of Luzon and some other islands of the Archipelago, or those portions of the Philippines which come under the first type of rainfall.

The northwestern part has much rainfall; the southwestern has distinct wet and dry seasons. For this reason, large areas of irrigated land are found in the northwestern part while large tracts of dry unirrigated land are found in the southwestern portion.

Table 3 gives an idea of the climate in different parts of Taiwan.

A climatic factor which is quite important in Taiwan agriculture is wind. In winter, strong winds blow north to west. In summer, typhoons come, damaging crops. The months of most frequent typhoons in Taiwan are July, August, and September, 28 per cent of them occurring in July, 35 per cent in August, and 21 per cent in September.

The area greatly affected by wind is a long strip of the western coast from 4 to 12 kilometers deep. There is also a short strip affected in the southern portion. In a district of Tainan, where the Lompai reclamation project is situated, the wind velocity varies from 10 to 20 meters per second. In this district some 4,000 kilometers of windbreak have been established.

Soil of Taiwan from the standpoint of rice culture.—Where rice is chiefly cultivated, that is in the western part of the Island, particularly the central and southern districts, the land is alluvial plains. The soil of the principal rice fields is generally speaking very heavy in texture, being derived chiefly, it is reported, from the disintegration of clay slate from sedimentary rocks. It is therefore quite adapted not only to lowland rice culture but also to the construction and maintenance of small water reservoirs for impounding rain water for irrigation purposes. In some places, however, the soil is quite sandy with very little clay constituent.

Generally, soil areas with acid reaction may be found in the northern part of Taiwan, while alkaline areas are encountered in the southern part.

Where soil is alkaline, the reaction is corrected automatically when it is irrigated for the irrigation water is reported to reduce if not neutralize the alkalinity. The soil of Formosa is said to have an average pH value of 5.7, while that of the Philippines, 5.1, which means that on the average Philippine soil is more acidic than that of Taiwan.

Taiwan soil is generally low in nitrogen content as may be gleaned from the following figures copied from a table in exhibit at the Government Agricultural Research Institute: Japan proper, 0.23 per cent N; Chosen, 0.15 per cent; Hainan, 0.06; Taiwan, 0.14 per cent. The average N-content of soils in the Philippines was considered 0.25 per cent. While the Taiwan percentage is low, it is, however, sufficient to meet the minimum requirement of rice soil.

In Taihoku Province, volcanic soil, andesite in nature, is found but not in other parts of Taiwan.

Kinds of rice culture.—As in the Philippines rice culture in Taiwan may be divided into lowland irrigated, lowland nonirrigated and upland. In irrigated fields either one or two crops of rice are grown, depending upon water supply and system of crop rotation followed. Under nonirrigated lowland condition, only one crop of rice is grown, the same being true under upland conditions.

In 1936 the two-crop rice occupied 327,438 hectares, while the one-crop 206,391 hectares, of the 872,000 hectares of agricultural land. According to an informant the area under first crop of rice in 1939 was 275,000 hectares which produced about 4,000,000 Koku of hulled but not polished rice, equivalent

to a yield of 14.6 Koku per hectare, while the area under second crop was 370,000 hectares with a production of 5,000,000 Koku or 13.8 Koku per hectare. The percentage of rice land on one and two-crop rice in different provinces for the year 1936 is shown in fig. 1.

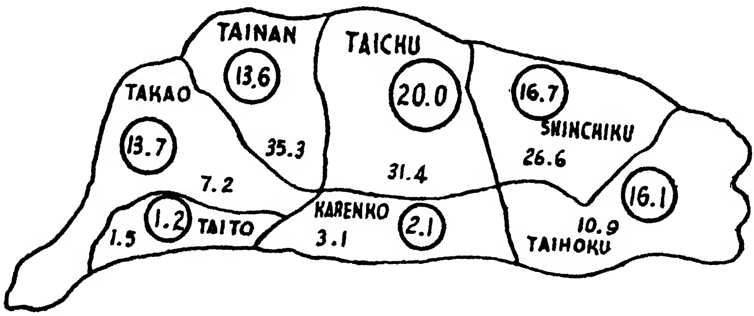


FIG. 1. Percentage of land on one-crop rice (numbers inclosed in circles) and on two-crop rice (1936). In Tainan the production of second-crop rice is about 3 times that of the first crop (1944), and the biggest in the entire island.

Planting mixed seeds of different varieties.—This is reported to be done in some places, as in some districts of Taihoku for the purpose of solving difficulties due to uncertain supply of rain water. Early and late varieties are mixed. The idea is that if there is not sufficient rain water to mature the late variety, at least the early variety could be expected to produce a crop.

Ratooning.—To avoid the damage caused by moonson tides, the rice crop is ratooned in some places. The varieties used are those resistant to saline water.

Varieties of rice in different provinces.—The principal varieties of rice grown in different provinces in Taiwan are those shown in Table 4. Of the varieties, Taichu 65 was reported to be the most widely grown, being not very susceptible to variation in length of day and in temperature.

TABLE 4.—*Varieties of rice principally grown in lowland culture in Taiwan.*

Province	Varieties	Remarks
Taihoku	Taichu 65 Taihoku 7 Taihoku 8 Taihoku 11 Taichu 150	All these varieties are used in two-crop rice culture.
Shinchiku	Shinchiku 4 Taichu 150 Taichu 65	These varieties are resistant to strong winds to which the province is exposed.

TABLE 4.—*Varieties of rice principally grown in lowland culture in Taiwan*—Continued

Province	Varieties	Remarks
Taichu	Taichu 150 Taichu 65	
Tainan	Taichu 150 Taichu 65 Kanan 2 Kanan 8 Also some native varieties.	Taichu 150 is used in two-crop culture, also Taichu 65to a little extent, Kanan 2 and 8 are used in one-crop culture, Kanan being a more predominal variety.
Takao	Kanan 2 Kanan 8 Takao 11 Takao 12 Takao 18 Also some native varieties.	Kanan 2 and 8 are used in this province for both two-crop and one-crop cultures. Takao 11, 12 and 18 are the newest varieties and are recommended for trial in the Philippines

In Takao some Taiwan varieties are still used, such as Seikochum and Ryuchum. Of the area occupied by native varieties, the former occupies 70 to 80 per cent while the second about 10 per cent. In the second crop these varieties are said to yield about the same as the Horai rice.

Performance of varieties.—This is given in Table 5.

TABLE 5.—*Comparative performance of some varieties as reported by the Taihoku Provincial Agricultural Experiment Station*

Variety	First crop	Second crop
Taichu 65	100 index	100 index
Taihoku 7	140	104
Taihoku 8	107	121
Taihoku 9	101	114
Taihoku 10	123	114
Performance in 1942 around Giran		Crop not given
Taichu 65		100
Taihoku 7		230
Kanan 8		200
Another variety		260

PARENTAGE OF SOME OF THE VARIETIES

Taichu 65 is a cross between Kameji as female and Sinriki as male parents, both being Japanese varieties. Taichu 150 is a cross between Taichu 65 and N. C. 4 (Italian variety). Taihoku 7, 8, 11, 12 and 13 are strains selected from Japanese varieties. Takao 10 is a hybrid.

The varieties of rice grown in Taiwan may be classified into lowland and upland, glutinous and nonglutinous. The areas

occupied by these different groups in 1936 were as follows, later figures not being available:

	Area Ha.	Production *bu.*
Lowland nonglutinous:		
Japanese (Horai Mai) varieties	299,018	23,196,010
Formosan (Zarai Mai)	271,275	17,507,230
Glutinous:		
Round-grained (Marumochi)	74,765	4,308,320
Oblong-grained (Nagamochi)	16,616	1,055,800
Upland:		
Nonglutinous and glutinous	41,011	1,724,590

Planting seasons and crop stages.—As may be expected, the planting season as well as the different stages of the growth of the crop varies in the different provinces on account primarily of climatic differences. Tables 6 and 7 give the different seasons of planting and the dates of occurrence of the growth stages of the crop. These were prepared by the assistants of Doctor Iso of the Agricultural Research Institute.

METHODS OF CULTURE

Standard method for Horai rice in brief.—Fig. 2, kindly furnished by Mr. Susuki of the Government Agricultural Research Institute, shows graphically the essential points in the method of culture which should be adapted in the growing of Horai rice in Taiwan. These data should serve as useful guides to those who might attempt to grow these varieties in the Philippines.

Seed bed.—For both the first and the second crops, the seed bed is 120 centimeters wide. If the bed is to receive hormone treatment, the dike surrounding the bed is made 8 centimeters high. The area of the bed is one-thirtieth of the area of the field which is to receive the seedlings.

TABLE 6.—*Planting seasons and crop stages of irrigated lowland rice in different provinces in Taiwan*

Province	Crop	Sowing	Transplanting	Heading	Ripening	Harvesting
Taihoku	1st	Jan. I [a]	Feb. II	May I E.[b]	June II E.	June II E.
				May II M.	June III M.	June III M.
		Feb. II	Mar. II III	May III L.	July I L.	July I L.
	2nd	June II III	July II–III	Sept. I E.	Oct. II E.	Oct. II E.
				Sept. II M.	Oct. III M.	Oct. III M.
				Oct. I L.	Nov. II L.	Nov. II L.

[a] I means first 10 days; II means second 10 days; III means last 10 days.
[b] E=early; M=medium; L=late.

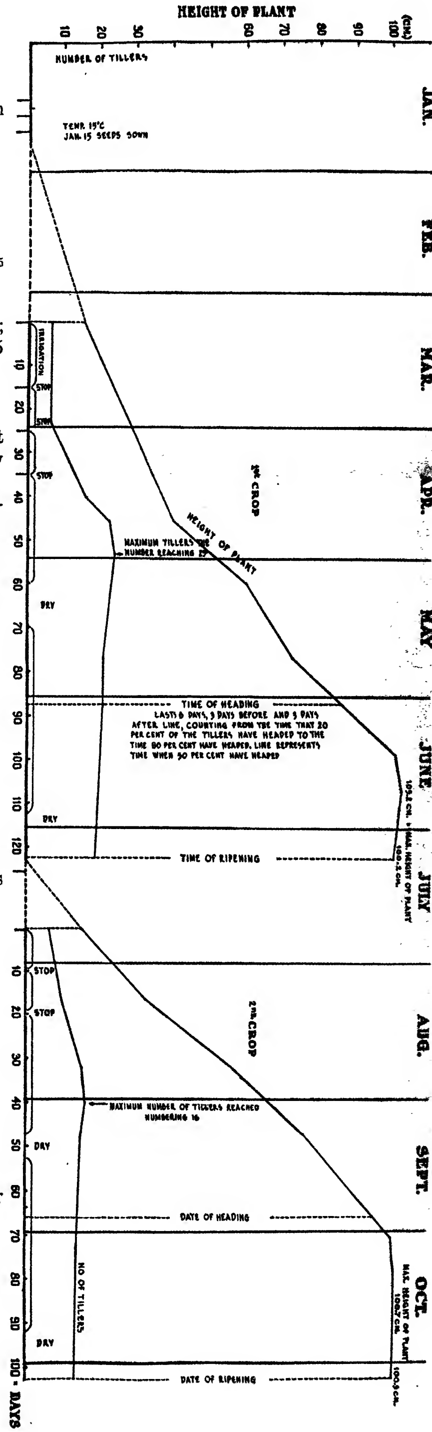
TABLE 6.—*Planting seasons and crop stages of irrigated lowland rice in different provinces in Taiwan*—Continued

Province	Crop	Sowing	Transplanting	Heading	Ripening	Harvesting
Shinchiku	1st	Jan. II–III	Mar. I-II	May III E.	June III E.	July III E.
		...	...	June I M.	July I M.	July I M.
		...	...	June I M.	July II L.	July II L.
	2nd	June II	July III	Sept. III E.	Oct. III E.	Oct. III E.
		...	...	Oct. I M.	Nov. I M.	Nov. II L.
		July I	Aug. I	Oct. II L.	Nov. II L.	Nov. II L.
Taichu	1st	Dec. III	Jan. II	May I E.	June I E.	June I E.
		...	...	May II M.	June II M.	June I E.
		Jan. III	Mar. III	May III L.	June III L.	June III
	2nd	June III	July II	Sept. III E.	Oct. III E.	Oct. III E.
		...	...	Oct. II M.	Nov. II M.	Nov. II M.
		July II	Aug. I	Oct. III L.	Nov. III L.	Nov. III L.
Tainan	1st	Dec. II–III	Jan. II	Apr. III E.	May III E.	May III E.
		...	...	May I–II M.	June I–II M.	June I–II M.
		...	Feb. III	May III L.	June III	July I L.
	2nd	June I	May III	...	...	
		...	...	...	...	
		July I	July II	Sept. II–III	...	
Takao	1st	Dec. I–III	Jan. I-III	Apr. I E.	May I E.	May I E.
		...	...	Apr. II M.	May II M.	May II M.
		...	...	Apr. III L.	May III L.	May III–June I
	2nd	June II	June III	Sept. III E.	Oct. III E.	Oct. III E.
		...		Oct. I M.	Nov. I M.	Nov. I M.
		July I	July III	Oct. II L.	Oct. II L.	Nov. II L.
Taito	1st	Dec. III	Jan. III	May I E.	Jan. II M.	Jan. I E.
		...	...	May II M.	Jan. I E.	Jan. II M.
		...	...	May II M.	June III to	June III to
		Jan. I	Feb. III	May III L.	Jul. II L.	July II L.
	2nd	June II	July II	Oct. I E.	Oct. III E.	Oct. III E.
		June III	July III	Oct. II M.	Nov. I–II M.	Nov. I II M.
		July III	...	Oct. III L.	Nov. III L.	Nov. III L.
Karenko	1st	July I–II	July I III	Sept. I E	Oct. II E.	Oct. III E.
		...	...	May III M.	June III M.	June III M.
		...	Mar. III	June I L.	July I L.	July I-II L.
	2nd	July I–II (Horai)	July I III	Sept. I E.	Oct. II E.	Oct. III E.
			...	Sept. I II M.	Oct. III M.	
		...	...	Sept. I-II M.	...	Nov. I M.
		June I–II (Native)	...	Sept. I–II M.	Nov. I L.	Nov. II L.

TABLE 7.—*Planting seasons and crop stages of upland rices (upland variety) in different provinces in Taiwan*

Province	Crop	Sowing	Heading	Ripening	Harvest
Taihoku	First Crop	Feb. III	May III	July I	July III
	Second crop	July I	Sept. III	Nov. I	Nov. II
Shinchiku	First Crop	Feb. II	June II–III	July II–III	July III
	Second crop	May II	Sept. II-III	Oct. II–III	Oct. II-III
Taichu	First Crop	Feb I-Mar I	June I–II	July I–III	July I–III
	Second crop	Apr. I-Mar I	Aug. II–Sept. II	Sept. II–Nov. I	Sept. III–Nov. I
Tainan	First Crop	Mar I-Apr. I	June I II	July III	July–Aug.
	Second crop	Apr. II–III May I–II	Sept. I	Oct. III	Oct. III
Takao	First Crop	...	...	...	...
	Second crop	May III–June III	Aug. I-Sept. III	Sept. I–Oct. III	Sept. I–Oct. III
Taito	First Crop	Jan. II–Feb. I	May I–II	June I–II	July II
	Second crop	July I–II	Sept. I–II	Sept. III–Oct. I	Sept. III–Oct. I–II
Karenko	First Crop	Feb.-Mar.	June I	June II-III	July I
	Second crop	June II–July I	Sept. I	Sept. III	Sept. III–Oct. I–II

[a] I means first 10 days; II means second 10 days; III means last 10 days.
[b] E=early; M=medium; L=late.



Seeds sown Jan. 15. Rate 4 go. per chubo, 1 seed each hill, hills 1.5 cm. each way.

Nursery period for first crop = 45 days

Manuring:
- Potassium sulfate, 100 kg. per Ha.
- Calcium phosphate, 500 kg. per Ha.
- Soybean cake, 500 kg. per Ha.
- Compost, containing 0.6% N., 0.2% to 0.3% P_2O_5 and 0.5% K_2O. 15,000 kg. per Ha.

Date of transplanting. Rate: Rows distanced 24–25 cm.; hills, 22–23 cm.; 18,000–20,000 hills per Ha., 5 plants per hill

First weeding 15 days after transplanting

Second weeding and manuring, 10 days after first weeding am. sulfate, 100 kg. per Ha., 10 cm. below ground surface, stirring the soil with hand

Third weeding, 10 days after second weeding. Succeeding weedings, every ten days if necessary

Time of sowing of seeds, July 8. Seeds soaked 2 days in water of ordinary temperature

Date of transplanting, July 23.
Nursery period for second crop is 15 days.
No manuring of seed bed.

Manuring of field. Rate of application same as for first crop.

Fig. 2. Graph showing phases of rice culture in Tainan in relation to months of the year.

Seed and seedlings and their treatment.—After and while still paying considerable attention to the question of choice of rice varieties, the government is at the same time utilizing fundamental scientific findings regarding seed treatment in efforts to enhance rice yields. One of these findings is that planting material produced at a higher elevation have larger yield in the lowland in case of some plants, than those produced at lower levels. The effect is only in the first generation. This fact was once used in sugar culture in Java, before resistant varieties of sugar cane had been produced, and cuttings for lowland use were raised on mountain nurseries where they acquired greater vigor. In the United States, it will be recalled, southern potato growers occasionally change seed by getting these from the colder North. In the Province of Taihoku in Taiwan, there is maintained a rice seed farm at a place called Chikusho, located at an elevation of 300 meters and where the average temperature is 15° C. After a variety is selected, seed is propagated and that for distribution to the growers is produced in a similar way. The size of the mountain seed is increased though not considerably. In this way, the farmer is obliged to use new seed every year and as may be expected, the system helps maintain the purity of seed. The seed raised on the mountain seed farm is reported to be larger and have higher specific gravity and therefore, on physiological grounds, could be expected to produce better seedlings than those which are lighter. It is said that sweet potato cuttings are also produced at the seed farm. According to Doctor Iso, the yield farm is not big enough to produce all the seed needed each year, so two years are required to produce the necessary amount. Other provinces also operate government ordinary seed farms. The Province of Tainan is operating a central and regional seed farms, while Taichu runs a seed farm for rice for each county.

The seed treatment for the first crop consists of the following: Seeds are soaked in water of room temperature for four days. On the fifth day, water one-half volume of the seed with a temperature of 50°C. is poured on the seed which is subsequently allowed to stand and the water to return to room temperature. On the sixth day, water of the same volume and temperature is again poured on the seed, once in the morning and once in the evening. On the seventh day, the seed is stirred and then soaked in the evening in water of room temperature. The seed is then ready to sow.

For the second crop, the seed is soaked in water of room temperature for two days and then sown directly. There is no hot water treatment.

Sowing of seed.—The method used in sowing the seed for the first crop is the same as that for the second. The seed is sown at the rate of 4 go per chubo,[2] equivalent to 2.2 liters per square meter. The seeds are spaced 1.5 cm. each way, one seed to a hill.

Application of hormones to seedlings.—Increased yield of rice is already being obtained not only in Taiwan but also in Japan by the application of one of the recent results in agricultural research. This is the stimulation of plant by the application of hormones or growth-regulating substances to plants. After five years of study Professor Shibuya of the Faculty of Agriculture of the Taihoku Imperial University found that the yield of rice can be increased about 10 per cent in the first crop and more than 20 per cent in the second crop by applying the hormone, heteroauxin, to the seed bed at the rate of about one gram to one hectare of rice field. It was reported that this treatment has already been applied on some 2,000 hectares all over the Island, while in Japan, some 100,000 hectares have already been treated. In 1945 it was planned to apply it on 20,000 hectares in Taiwan. The hormone used is indole-acetic acid manufactured by Takeda Pure Chemicals Ltd. and by Sankyo, both in Tokyo, Japan, and used to sell at about 5 yen a gram. Due to high demand, the supply of this chemical is not sufficient, so in Japan another chemical, naphthalene acetic acid, is used. This acid is harder to use on the part of the farmers because it is used at a lower concentration, 1/10, and an over application results in injury to the plants. It is cheaper, costing about 1 yen a gram. To use the hetero-auxin, which is in powder form, one gram of it is dissolved in 300 liters of water and applied to 100 chobu (330 square meters) of seedbed in which water is 8 centimeters deep ten days to two weeks before transplanting in the first crop and 9 or 10 days in the second crop. Two to four hours after the application the water is allowed to dry. The seedlings from this area of seedbed are sufficient to plant a hectare of rice field. The data in Table 8 were kindly furnished by Professor Shibuya as a sample of the results of experimental use of plant hormone.

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[2] 1 go = 1.8 liters; 1 chubo = 3.3 square meters.

TABLE 8.—*Results of applying (plant) growth hormone to increase the yield of rice grain.*

		Growth hormone given per Ha.	Length of a panicle	Number of panicles	Yield of unpolished rice per hectare	Ratio
		Grams	*cm.*		*Kilos.*	
Second crop		12.00	16.5	14.7	3435.5	108
		6.0	16.6	12.9	3350.4	105
		3.0	16.9	13.8	3486.7	110
		1.5	16.9	13.4	3320.1	104
		0.6	16.9	13.2	3479.6	109
	Control	...	16.6	13.0	3182.1	100
First crop		3.0	21.7	11.4	4028.4	121
		1.8	21.1	10.9	3885.0	116
		1.2	20.9	11.0	4556.8	136
		0.6	20.6	11.5	3695.8	111
		0.3	20.7	10.8	3515.3	105
	Control		20.8	10.6	3342.4	100

Seedbed.—The bed is prepared very thoroughly and manured for the first crop but not for the second. Ammonium sulfate, compost and ash are used for fertilization. The fertilizer and manure are supplied either in one or in two instalments. If applied in two instalments, the second application is made shortly before planting.

In Taihoku for the first crop, the seedlings of Horai varieties are allowed to grow in seedbed until they are 40–45 days old when they are transplanted. The seedlings of the second crop are transplanted at the age of 20 days. The longer nursery period allowed the seedlings for the first crop is due to the lower temperature of the air prevailing during the nursery period. In Takao Province, seedlings are 25 to 35 days old when transplanted for the first crop and 15 to 20 for the second.

In Taiwan it is well known that in order to produce good rice crops it is necessary to transplant vigorous seedlings. Because of shortage of farm labor being felt at present, individual farmers cannot pay the necessary attention to their seedbeds, as for example in the control of pests and diseases. To obviate such difficulties, the government is encouraging the farmers to operate co-operative seedbeds. This is done for example in the Province of Shinchiku.

Preparation of land for transplanting.—The preparation begins soon or immediately after harvest. The ground is plowed dry, which is not submerged in water, as is usually done in the Philippines, the depth at which the soil is plowed being 4 to 5 inches. Deep plowing was found beneficial. After plowing, the field is harrowed 6 times, 3 times each direction. The field is then plowed once more, then water is turned in, then

harrowed. Two kinds of harrow are used—a horizontal tooth harrow equivalent to the Philippine *calmot,* and a vertical tooth harrow similar to our *suyod* for finishing.

Transplanting.—Before the annexation of Taiwan to Japan, the farmers planted their rice by broadcasting the seed. Now this method has been almost entirely abandoned in favor of transplanting seedlings. It is said that in the northern portion of Taiwan it is the practice to transplant the seedlings with soil adhering to the roots. In the southern portion they are transplanted without soil attached to the roots. Seedlings of Horai rice are not pruned or topped before transplanting, but native varieties are topped for second crop.

An important characteristic of the present method of transplanting rice in Taiwan is the planting of the seedlings in straight rows. To be able to do this, markers of rows and holes are used. The simplest marker utilized is a long piece of string to indicate the row end on which are marked the position of the holes. A more elaborate marker was seen at the Kobi Sugar Central. This marker is made essentially of a bamboo pole about 2 centimeters in diameter and 3.3 meters long to which 16 pieces of the same kind and size of bamboo stem are attached perpendicularly, the two at both ends being longer, and distanced 24 centimeters apart. These serve to mark the rows in one direction. These perpendiculars are themselves marked with notches supplemented with fiber bristles to mark the position of the holes in which the plants are to be planted. These notches are 22 centimeters apart. Figure 3 serves to illustrate this marker.

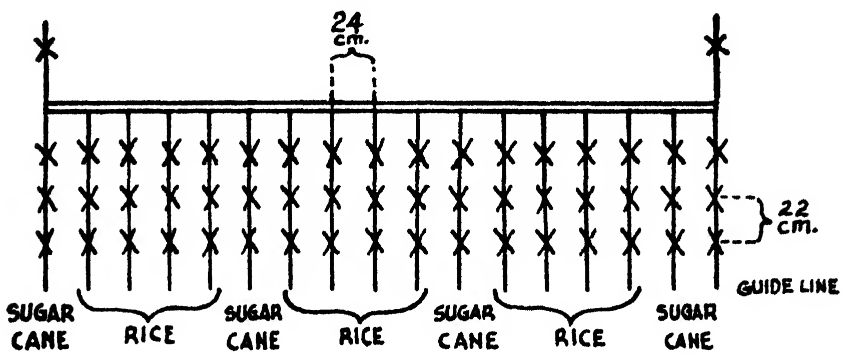

FIG. 3. Marker for spacing sugar cane and rice hills.

Incidentally, this marker is used for the rows of sugar cane when this plant is intercropped with rice, the marker marking 12 rows of rice and four of sugar cane in each new position after transplanting the area it previously covered.

A third marker used in Takao is shown in fig. 4. It is said to be available in the markets at a price of 18 yen. It is essentially a triangular frame the base of which is provided with 13 teeth to serve as markers of rows. It is first drawn over the field to mark parallel rows. Then it is drawn perpendicularly to the first rows, and where the lines intersect, the rice seedlings are planted.

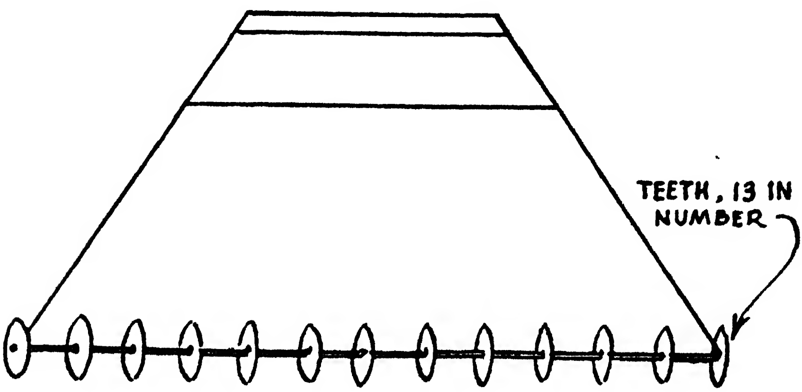

FIG. 4. Markers for spacing rice hills.

For the first crop, seedlings are transplanted when 45 days old and for the second crop, 15 days old.

The rows of rice plants are distanced 24 to 25 centimeters apart while the holes or hills, 22 to 23 centimeters apart in the row. Five seedlings are planted in each hole. The seedlings are planted as shallow as possible, not more than one inch deep.

For lifting rice seedlings from the seed bed, there is used in Taiwan, flat iron hand trowel with broad, nonpointed and slightly curved base end. The blade is 6 inches long and 4.5 inches wide and attached to a 1-meter wooden handle. From this trowel the seedlings are separated one by one and then transplanted.

Sometimes, the soil of the bed is manured and the seedlings are transplanted with manured soil.

Rate of transplanting.—An experiment has been completed at the Agricultural Research Institute in which it was found

that for every 3.24 square meters of space, it is necessary to plant only 350 to 400 seedlings, no more no less, to obtain the highest yield. The seedlings may be planted one to the hill, although it is recommended that 3 to 4 seedlings be planted in each hill. This method of planting is aimed at obtaining only the main culm and first group of tillers and the prevention of the outcropping of the secondary or second group of tillers. It is estimated that 65 to 70 per cent of the yield of the plant is borne by the first group of tillers and 30 to 35 per cent by the main culm. The result of this experiment will now be applied in the field.

Cultivation and weeding.—These two processes are done almost simultaneously. The rice field for the first crop is cultivated three times, the first time being done 15 days after transplanting, the second 10 days after the first weeding, and the third, 10 days after the second. It is said that some roots are probably cut during the first cultivation. In the second cultivation the field is fertilized with ammonium sulphate at the rate of 100 kilograms per hectare. The soil is cultivated to a depth of 2 to 4 inches. If succeeding weeding becomes necessary, it is done every 10 days after.

In cultivation, the natives use their hand, one person being able to cultivate one-tenth of a hectare a day starting from early morning until evening and resting for about three hours during the hottest part of the day. In the other cases an iron hand cultivator, a sample of which is already found in the Philippines, is used. In Taiwan this cultivator is said to cost 5 yen and is 5 times as efficient as the bare hand. The sample in the Philippines contains only one roller. A two-roller type is also used in Taiwan (fig. 5).

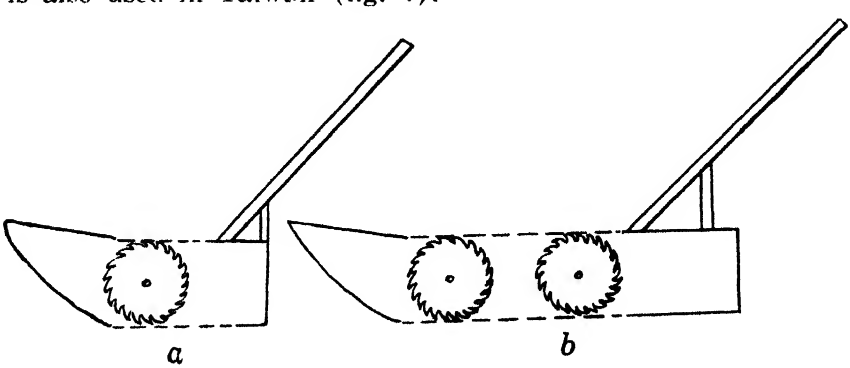

FIG. 5. *a*. One-roller type of rice cultivator-weeder; *b*, two-roller type.

Fertilization, including the application of manure and compost.—Before the outbreak of the current war, Taiwan had been importing large amounts of mineral fertilizers for use in the improvement of yield of different crops including rice. At present, however, there is practically no mineral fertilizer being brought into the country. However, the high levels of yields of different crops have been maintained no longer by the use of imported mineral fertilizers but by the utilization of local manures and compost including night soils.

Each farmer is required to prepare such amount of local manure as is calculated to supply the area he is cultivating. The local manure is a mixture of animal manure, straw of rice and other vegetable matters available, and night soil. The animal manure is chiefly that of carabao and pigs, the carabao being the work animal on the farm and each farmer being required to raise pigs. Considering the method of preparing local fertilizers it is not necessary to discuss the subjects of manuring and use of composts separately since they are prepared and applied in a mixed form. For convenience, the term fertilization will be used to apply to these separate practices inasmuch as this term signifies the addition of anything that serves to increase the fertility or yielding capacity of the soil. The amount of locally made fertilizer applied varies according to the fertility of the soil. In Taihoku Province each farmer is asked to prepare 18 tons of finished composts per hectare for the first rice crop and 12 tons for the second. It appears that in some provinces at least night soil is not used in rice culture. In Taihoku, for example, night soil is said to be applied to vegetables only. In Takao locally made compost is applied at the rate of 12 tons per hectare; green manure, about 16 tons; and mineral fertilizers, 3 to 5 piculs as against 7 to 10 previously.

The first crop is manured before and after transplanting, while the second, only after transplanting.

The materials are applied together and the amount of each used per hectare before transplanting is 15,000 kilograms of compost containing about 0.6 per cent N; 0.2 to 0.3 per cent P_2O_5 and 0.5 per cent K_2O; 500 kilograms of soybean cake; 500 kilograms of calcium phosphate; and 100 kilograms of potassium sulfate.

The fertilization of the first crop after transplanting takes place 25 days after transplanting. At this time 100 kilograms of ammonium sulfate is applied per hectare, 10 centimeters

below the surface of the ground, stirring the soil with the hand while applying.

In connection with fertilization it was explained that Horai rice plants absorb nitrogen actively from the 25th to the 55th day after transplanting. From this day absorption begins to decline. Absorption of phosphorus begins 10 days before heading time and promotes heading. Potash is absorbed during the entire lifetime of the crop.

The fertilization of the second crop takes place 60 days after transplanting. The same material and rate used for the first crop are used for the second.

Green manuring.—The plants used for green manuring rice land in Taiwan are given in Table 9 furnished by Mr. T. Abe.

TABLE 9.—*Plants used as green manure in Taiwan.*

Part of Taiwan	Northern Taiwan	Central Taiwan	Southern Taiwan
Kind of land:			
Irrigated land:	*Phaseolus lunatus* Rootless radish (daikon)	Soybean A red-flowered pea. Rootless radish	*Sesbania sesban.* Soybean. Red-flowered pea.
Dry land	Some *Crotalaria* and some soybean	*Sesbania sesban* Some *Crotalaria* Some soybean	*Mucuna capitata* (akin to velvet bean) much *Sesbania*, some *Crotalaria*, much soybean, and red flowered pea.

The identity of the red-flowered pea cannot yet be given. This plant is planted for food and for green manure in alternate years. For food and seed, it is planted broadcast in September or October and is harvested in January or February. For green manure, it is planted in January and is plowed under the following months, at which time the plants are less than 2 meters in length. The dates of planting vary according to districts.

In green manuring, the green manure crop may sometimes be planted as a Koa crop, that is, planted to overlap the rice culture. A more detailed description of this culture method is given later in this report. An example of this is found in the practice in Toroku municipality, Taiwan Province. The first crop of rice is planted in March and harvested in June. Before the harvest, green manure is already planted. From the end of July to the beginning of August, the second crop is planted and is harvested in November. Flax, wheat, sweet potato are also planted under the Koa system.

In Takao we were informed that the yield of rice is increased 30 per cent by the application of black soybean green manure, about 6 tons of the green manure being applied per hectare. The green manure is first planted to a dryland crop, then after 10 days water is turned in. When the crop is about 100 days old, it is turned under, at which age the plants are about 50 to 80 centimeters high. Soybean is used for the first crop and *Sesbania sesban* for the second. *Sesbania* is planted after the first crop and the soybean after the second. For dryland green manuring, *Mucuna capitata* is utilized.

Dr. T. Tanaka reported that in 1936, the area occupied by green manure was 202,000 hectares of which 150,000 hectares was wet land and 52,000 hectares dry land.

Irrigation.—Provided water is available, the soil is always kept covered with water but as shallow as possible, and moving slowly at the rate of 1 cubic shaku per second. At this rate, 1 Ko (0.97 hectare) of moving water irrigates 15 hectares.

For the first crop, irrigation water is applied in 5 periods with brief intervals in between. The first period lasts 15 days, counting after transplanting; the second lasts 10 days; the third, 10 days; the fourth, 25 days. After the fourth, water is stopped for 10 days. Then it is applied for the fifth time, this fifth period lasting about 42 days. Then the field is allowed to dry preparatory to harvesting.

For the second crop there are four periods of application beginning after transplanting, the first period lasting 10 days; the second, 10 days; the third, 25 days; and the fourth, about 42 days. The rest intervals are short except between the third and the fourth when the interval or rest is 6 days. After the fourth period, the field is allowed to dry preparatory to harvesting. The application of water ceases shortly before harvesting. Before this time, the native rice growers do not allow the soil to dry as it becomes hard and is difficult to cultivate. The depth of water in the field is about 5 to 6 centimeters after transplanting. At tillering stage, it is about 10 centimeters. Fifty-five days after transplanting maximum tillering is obtained at which stage the water is kept as shallow as possible. Heading begins 80 to 90 days after transplanting. This is a critical stage in the life of the crop. If irrigation water is deficient at this time, the number of normal heads suffers a decrease. After the maximum number of tillers is reached, water is withdrawn. Ten days before this stage is

reached, the water is kept deep for 10 days, then the water is allowed to drain, the soil to dry, ready for harvesting. Another information obtained in the conference at the Provincial Government Building at Taihoku is to the effect that the duty of water for rice is 1 cubic foot per second for 5 hectares, if newly cultivated, or 1 cubic foot per second for 18 hectares on old fields, applied 90 days for the first crop and 85 days for the second.

Pests and diseases and their control.—Undoubtedly the worst pest of rice in Taiwan is the rice stem borer *Schoenobius incertellus* Wlk. Most of the fields that came under the writer's observation were very badly affected by this pest, the degree of damage being greater than any he had observed in the Philippines. The degree of borer infestation has been estimated to be 2 culms for every 15. As to disease, it is said that the most serious is the rice blast caused by *Piricularia oryzae.* This is serious on the first crop because of the wet and warm condition during heading time of rice. Attempts are being made to select and breed rice varieties resistant to the borer and to the blast. In different counties, of Taihoku for example, many varieties were tested for resistance to diseases and such varieties as were found resistant have been recommended to the farmers for planting. The tests were made right in places where the disease is prevalent. However, no artificial inoculation of the rice plant with the disease is made in the test. The native varieties are said to be resistant to diseases, and crossings have been made between these varieties on one side and the hybrid Taichu 65 and the Japanese variety Ashi on the other. Of the hybrids produced more than 100, numbered Taichu above 100, have been selected.

As a direct control measure against rice stem borer, it is said that the plants on the seed beds are observed for eggs of the insect and leaves found with them are cut and added to the compost piles. In the field the stems attacked are pulled up and burned. Evidently, these measures are not sufficient to control the pest since, as already reported, Taiwan rice fields show a high degree of infestation.

Other control measures employed against the borer according to Dr. Yushiro Miwa, Entomologist of the Agricultural Research Institute, are the following: (1) Tobacco dust is applied at the rate of about 5 pounds per *are* just before hatching of the eggs; (2) the second crop is plowed under the soil submerged for 2 weeks before using the field again; (3) light trapping; and (4) spraying with nicotine sulfate on the seed

bed just before transplanting. The nicotine sulfate is made in Japan and contain 40 per cent nicotine. Derris cannot be used because it will kill fish and is against the law. The water with derris may enter the rivers and cause damage to the fish. Damage caused by borer is 2 culms for every 15.

Harvesting and threshing.—With the first crop, harvesting occurs about 120 days after transplanting. At this stage the Horai rice plants are about 100.2 centimeters. However, this is not the maximum height of the plants. The maximum height, about 103.2 centimeters, had been reached between the 100th and the 110th day after transplanting. The maximum number of tillers, 25 per hill, is reached between the 50th and the 60th day after transplanting. The heading time lasts about 6 days and occurs during the early part of June or between the 80th and the 90th day after transplanting. The roots of the plants reach a depth of 50 to 60 centimeters.

With the second crop, harvesting occurs about 100 days·after transplanting. At this stage the plants are about 100.3 centimeters high, having reached the maximum height of 100.7 centimeters about 70 days after transplanting, and the maximum number of tillers of 16, about 40 days after transplanting.

In its trip in Taiwan Province the commission was able to see the actual operation of harvesting and threshing rice in a field, between the Osanto Dam and the Sinka Horse Breeding Station. The work was being done by several groups of men and women, each team consisting of 16 persons, 6 of whom doing the cutting, 6 the threshing, 3 the sieving and partial winnowing, and 1 separating broken straw from the sieved grains and putting these in sacks. The group operates more or less as follows: The six cutters, each equipped with harvesting knife which is not much unlike our *lilik* in the Philippines, and assigned one row at a time, cut the rice plants about 20 centimeters from the ground cutting as much as each could conveniently hold and then, without bundling the cut plants, laying these crosswise half spread in the same row where they were cut. Here they are picked by the six threshers, one of them attending to one row, and brought to the portable thresher nearby for threshing, after which the straw is returned to the same row and placed in the same position in which it was before. The threshed grains are taken to a hanging sieve (fig. 6) and sieved to separate most of broken straw. If there is a fairly strong wind blowing, the grains are partially winnowed as they fall from the sieve to a large circular basket placed directly below the sieve. One person attends to the grains

that have passed through the sieve. He or she removes the broken straw that are found on top of the pile of grains with the help of a short broom, and then puts the grains in the sack. The broken straw is flailed by simple beating with pieces of bamboo and the additional grains obtained are added to the main bulk. The cleaned rice, now in sacks, is taken home and dried, usually on a floor in front of his house, by the individual owners.

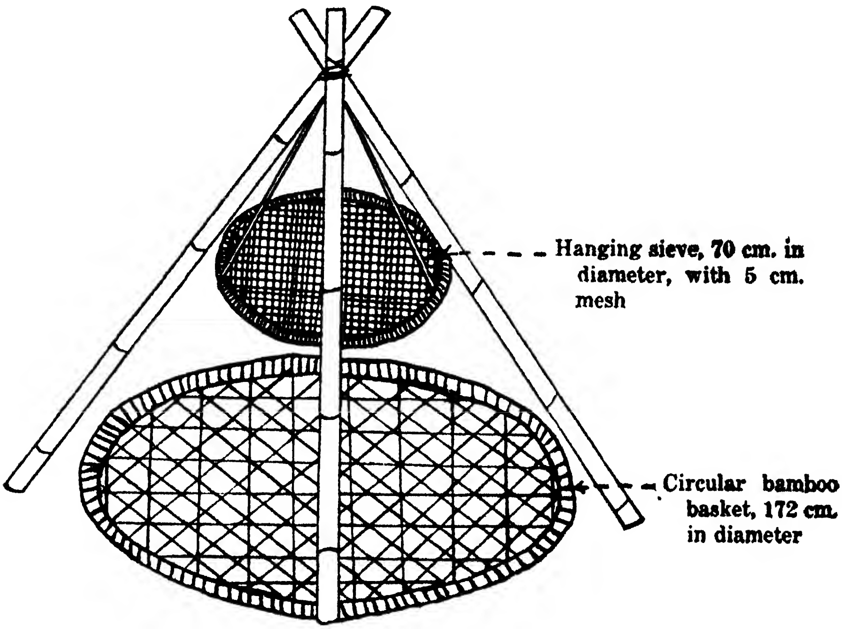

FIG. 6. Sketch of combined hanging sieve and winnowing device.

The members of the harvesting and threshing group were supposed to be working cooperatively, such group being capable of harvesting, threshing and sacking in a day the rice from 0.5 hectare of rice field equivalent to 3,000 kin (1 kin = 600 grams) of palay grains, working 6 or 7 hours a day.

The thresher used is of the same type as that which has been introduced in the Philippines from Japan. As used however, and to facilitate its being moved from place to place, it is placed in a large box mounted on a very low sledge pulled by carabao.

In some parts of Taiwan, rice is still threshed in the primitive way of beating the rice panicles against a standing slab of stone just as is done in the Philippines. The writer saw

this being done on the way between Kisan municipality and Takao City.

Storage of harvest.—Previously rice growers stored their harvest after the necessary drying in large bamboo baskets, provided with grass roofing and coated with clay and fresh carabao dung (fig. 7). Now, farmers are organized in associations which have bodegas where the rice of the members

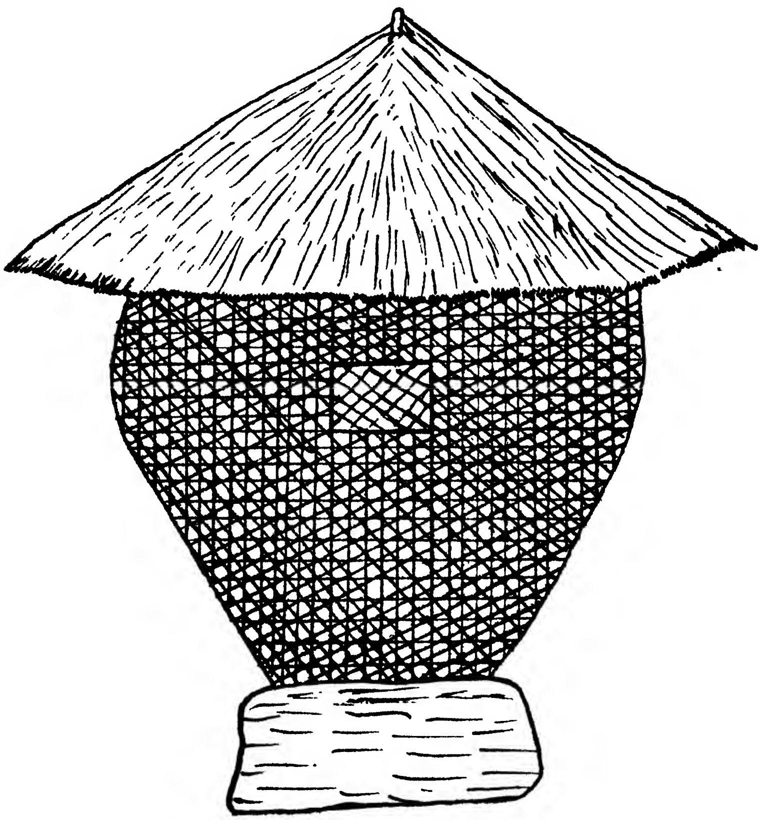

FIG. 7. A large bamboo basket provided with grass roofing and coated with clay and fresh carabao dung where rice harvest was formerly stored.

are stored and milled conveniently. In Tainan and probably in other provinces also cooperative drying of rice is undertaken.

Information obtained from Professor Shibuya of the Taihoku Imperial University was to the effect that stored seed should have under 13 per cent moisture, while for table purposes, rice should have about 16 per cent moisture and previously dried, preferably under shade.

Milling.—As in the Philippines, rice is in some remote barrios or village of Taiwan still prepared or cleaned by pounding it in large wooden mortars with wooden pestles and mallets very similar in construction to those in the former country, except that the pestles are longer and more slender. The writer saw these devices in a village near Nitsigetstan.

However, the big bulk of rice, particularly that for export, is undoubtedly cleaned in modern mills. Many of these mills are privately owned; others are operated by agricultural associations. In Taichu Province alone there are said to be a hundred rice mills. The Commission visited one of these mills operated by the Taichu City Agricultural Association. Operating 10 hours this mill has a capacity of 600 sacks a day, each weighing 60 kilograms. The milling recovery is 78 to 79 per cent, the polishing allowed by law being 70 per cent. The milled rice which goes to the Government is first inspected and graded by its inspectors before it is collected. The high percentage of recovery is due partly to the fact that as a war measure the rice is not polished as well as in normal times, and is somewhat brownish still as it comes out of the mill.

Windbreaks in rice culture.—The planting of trees as windbreaks for the protection of rice as well as of other crops and for the prevention of wind erosion in sandy districts is one of the noteworthy features of crop culture in Taiwan. Rice not protected by windbreak yields only from 70 to 80 per cent as much as that with protection. Undoubtedly one of the advantages derived by the rice crop from the windbreak is that it protects the plants against the adverse effects of strong wind on pollination. Samples of rice shown the writer in Taihoku Imperial University and harvested from fields without windbreak protection is very chaffy and appeared of very poor quality. Doctor Iso said the quality is lowered 1 grade, and 50 sen per sack in price. In addition it serves to protect the soil against undue evaporation of moisture and this is important where there is not sufficient rain or irrigation water for the successful production of a crop.

The species of plants commonly used for windbreaks are *agoho* (*Casuarina*), bamboos, and narra. Commonly, the trees are planted in single or double rows. However, for prevention of wind erosion the rows may number up to seven. When planted in single rows, the trees are distanced 0.7 meter apart; in double rows, the trees are distanced 1 meter apart and the

rows, about 0.5 meter, and the plants are arranged in triangles (quincunx).

The distance between groups or bands of windbreaks in rice fields is 150 meters.

The Agricultural Research Institute has done a large amount of experimentation on windbreaks, and Doctor Iso told the writer that the entire increase in production of rice and sugar cane due to the utilization of windbreaks all along the western coast on a strip of the Island 4 to 12 kilometers wide at the instruction of Doctor Iso is valued at some 25 million yen. The increase yield in rice is 20 per cent on the average, varying from 10 to 30 per cent but may go up to 50 per cent.

Doctor Iso gives a formula for determining the distance between windbreak rows. It is 20 times the height of the plants used.

A difficulty encountered in the use of *agoho* is that it is attacked by a stem borer which the Japanese call *tenyu* and claimed to be *Melaneuster chinensi* Forester.

The data in Table 10, furnished by Professor Shibuya of the Taihoku Imperial University, are examples of the results of utilizing windbreaks for the protection of rice and cane crops.

TABLE 10.—*Benefits derived from windbreak.*

	Region with windbreak	Intermediate region	Region without windbreak	Nature of index
Rice	100	96	80	Yield.
Sugar cane	100	100	83	Do.
Do	100	73	64	Sucrose content.
Do	100	87	80	Healthy stalks.

Rotation of rice with other crops.—The following systems have been used:

1. For hilly land
   Upland rice and sweet potato
2. For upland plain
   a. Unirrigated
      Upland rice and sugar cane—one year rotation.
      Upland rice, sweet potato, catch crop, sweet potato and sugar cane—three-year rotation.
      Upland rice, sweet potato, sugar cane (plant) and sugar cane (ratoon)—four-year rotation.
      Upland rice, sweet potato, catch crop, sugar cane.
      Upland rice, sweet potato, upland rice, sweet potato, upland rice, sugar cane—three-year rotation.

b. Irrigated

Green manure, lowland rice, sweet potato, sugar cane—three-year rotation. Rice is grown only once a year.

3. For lowland

a. Rotation on lowland where 2 crops of rice are possible and covering 322,000 ko.

One-year rotation.

	ko.
Rice, rice, green manure	78,311
Rice, sweet potato	10,000
Rice, rice, vegetables	10,000
Rice, green manure, rice, green manure	12,000

Two-year rotation.

Rice, rice, sugar cane	4,000
Green manure, sugar cane	1,800
Rice, sugar cane	1,500
Rice, sweet potato, green manure, rice, rice, green manure	2,000
Rice-tobacco	

Three-year rotation.

Rice, rice, sugar cane, sugar cane ratoon	2,700
Rice, sugar cane, sugar cane ratoon	1,300

b. Rotation on lowland where only one crop of rice is possible and covering 190,000 ko.

One-year rotation.

	ko.
Rice (Spring) sweet potato	8,000
Rice (Summer), green manure (winter)	10,000
Upland rice, sweet potato	3,000
Green manure, rice, sweet potato	2,500
Upland rice, paddy rice	2,000
Single crop rice, sweet potato, beans	......

Two-year rotation

Rice, sweet potato, rice, bean	2,000
Green manure, sugar cane	2,000

Three-year rotation

Upland rice, sweet potato, green manure, sugar cane	1,000

Four-year rotation

Upland rice, sweet potato, upland rice, sweet potato, upland rice, sugar cane	2,300

In the Province of Taihoku, to prevent rice land from being idle during the months of November to February, other crops are grown, such as vegetables, flax, and wheat.

Intercropping of rice and other crops or Koa culture.—As stated elsewhere in this report, other crops are intercropped and planted to overlap with rice, and this method of culture is termed "Koa." Koa is a Taiwanese word meaning "paste" and refers to the sticky consistency of rice soil. This is rather a comparatively new method of crop culture in Taiwan agriculture which was developed by Dr. E. Iso, of the Agricultural Research Institute. He found that it is possible to grow another crop following rice even if the land has no irrigation provided the other crop is planted before the soil becomes too dry and hard for convenient tillage and for supporting another crop. The best time found for this planting is about 30 days before rice is harvested or at about heading time. At this time the soil is still soft and sticky, hence the term "Koa." This method of culture is specially adapted in the southern part of Taiwan where rain is not abundant. At first only sweet potato was used. Later, it was found that sugar cane could also be grown that way with greater convenience and good results. Still later it was applied to wheat and flax and is now used intensively. After the rice is harvested the soil is so treated as to conserve the moisture as much as possible for the remaining crop. For example, in the case of sweet potato, the land is plowed and harrowed and then hilled toward the row of sweet potato.

The arrangement of rows of rice and the Koa crops varies according to the crop. In the case of sugar cane, there is a row of this after every 4 rows of rice, the distance between the rows being 24 to 25 centimeters. This means that after the rice is harvested, the rows of cane would be 120 to 125 centimeters apart. The cane cuttings, each containing two nodes or buds, are laid end to end or with the ends somewhat overlapping (fig. 9).

Sweet potato rows are also distanced about 125 centimeters apart. In the case of wheat, it is sown after every other rice row, after the soil is tilled.

In planting sweet potato care is taken not to plant it before heading time of rice because it affects adversely the rice heading. Planting sweet potato before the heading time of rice is said to be favorable for sweet potato but unfavorable for rice. Sweet potato and wheat are usually planted in the middle of October, while the cane, in the middle of September.

In Taichu Province the crops used for Koa culture are sugar cane, sweet potato, flax, wheat, and vegetables. These crops

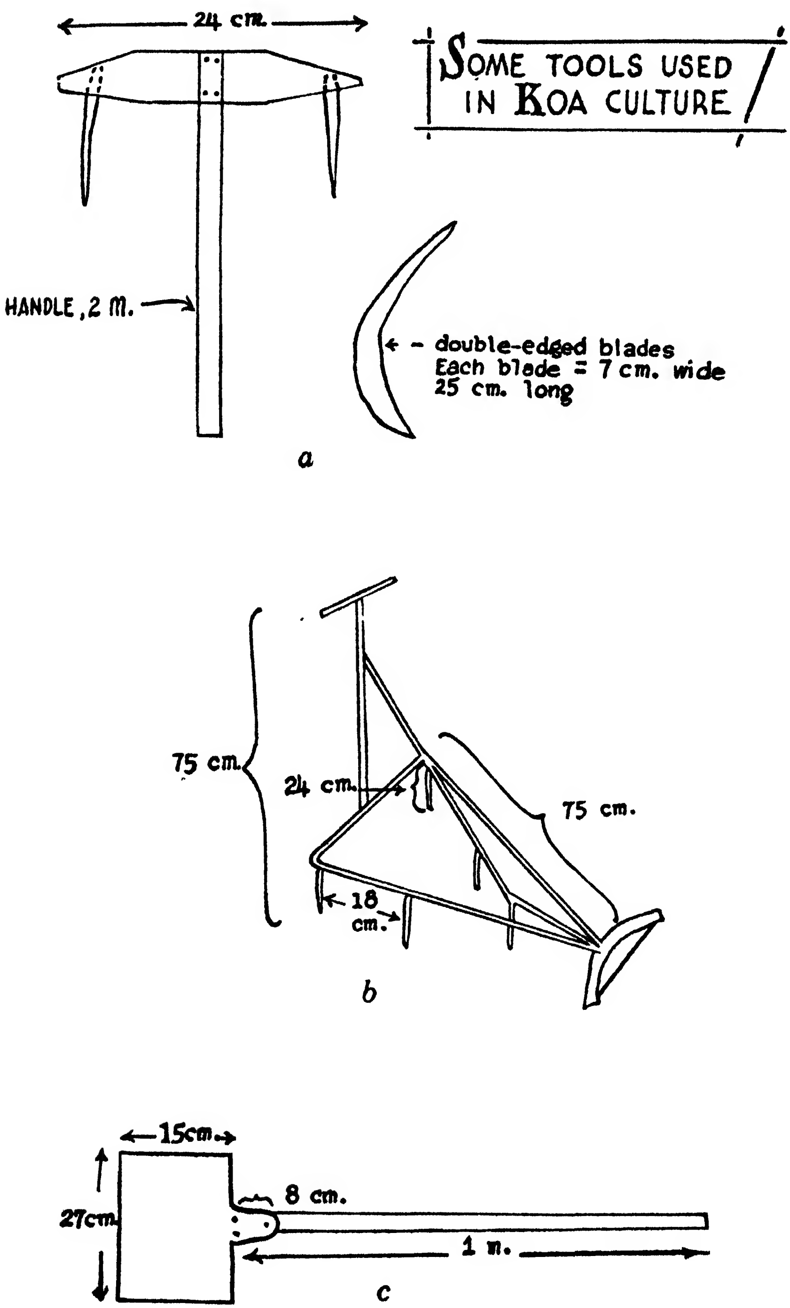

FIG. 8. Some tools used in Koa culture. *a*, A tool for cutting cane roots operated with a backward pull; *b*, a harrow made of iron; *c*, a flat shovel for lifting blocks of soil after being cut by the double-edged cutter.

are planted before the harvest of the second crop of rice and harvested before the planting of the first crop.

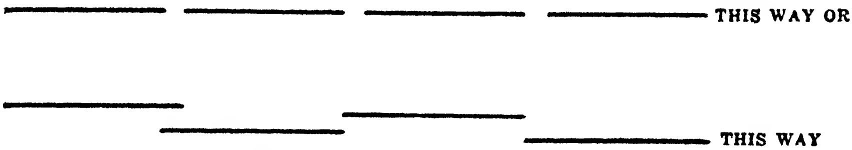

FIG. 9. Arrangement of cane cuttings.

In Tainan Province one of the crops used for Koa culture is sweet potato. After two crops of rice, the water is drained before the rice is harvested and the sweet potato planted. It is harvested in February of the following year, the crop lasting 4 months. If planting is delayed, the yield is less. The best time of planting is August and September and the harvest, April and May, but under the Koa system it is not feasible to plant in these months.

Use of dikes.—Occasionally, jute and ramie were seen growing on rice dikes presumably for land economy.

Uses of the rice plant.—Besides being used as food, the milled rice is used in Taiwan in the manufacture of the Japanese national wine, the *sake*. The rice bran is used as animal feed, 20 per cent of the feed given to pigs being rice bran. The straw is used in the manufacture of woven sheets for wrapping purposes, rope for tying, and for the making of rice bags or sacks for containers of rice grains and other stuff. The straw is also used as fuel in places where fire wood is scarce. A very important use of the straw is in the preparation of compost. The rice hull is used as a component in the construction of walls of village houses, the other components being clay, fresh carabao dung and lime. The hull is burned in certain places to produce ash which is used as a fertilizer.

Yield of rice crop.—The average yield of rice given for Taiwan is 13 koku per hectare. In Takao Province a ten-year average yield is 16 koku, hulled, per hectare for the first crop and 12 koku for the second crop of lowland rice. These yields are for Horai and native rices. At the time of annexation the average yield was only 6 koku per hectare. In Taichu Province the average yield of first and second crop is 15 koku per hectare. In a village of this province, Kadang, the yield per hectare was reported as 6,500 kin (one kin = 600 grams) for the crop and 6,000 kin for the second, the yields being in palay. In Sanjikitory village, noted for being in the best rice

region of the province and where we observed practically no borer-damaged rice fields, the yield per hectare reported is 8,000 kin for the first crop and 7,000 for the second. In Toroku municipality, Tainan Province, the highest yield reported is 18,000 kin per hectare.

The yields given above for the first crop are higher than for the second. However, according to Doctor Iso, the second crop generally yields more, 80 per cent, in northern Taiwan, than the first crop.

Distribution and marketing.—On account of the emergency arising out of the war, a rice farmer may not keep all the rice he harvests or his share. Only a certain amount may be kept by him. The rest is purchased and disposed of by the Government. Since November 1, 1939, the government has been carrying out a policy of rice gathering and distribution, including exportation.

According to Professor Okuda, of the Taihoku Imperial University, the government pays to the rice growers about 50 yen for each 1,000 kin (6 kilograms) of hulled rice given by him. An additional compensation of 30 yen per 1,000 kin of palay is given to the farmer if he supplies above 90 per cent up to 100 per cent of the quota required of him, and an additional bonus of 22 yen per koku of excess, and if above 100 per cent, the bonus per koku is 70 yen.

When the government distributes the rice it charges 2.88 yen per 10 kilograms of polished rice. Since the buying price offered by the government is higher than the distribution price the government loses in the rice control business. However, profit is not the objective but equitable distribution.

The following describes the policy of the government in its rice control and was copied from No. 15 (1943) issue of the *Nippon Today and Tomorrow.* It is assumed that since the promulgation of this policy, it has suffered some minor changes.

The rice policy in Taiwan is based on the Taiwan rice export and shipment control ordinance, under which rice control is enforced in the island side by side with rice export and shipment control. As fundamental regulations there are various rules based on the above ordinance and rules providing for the investigation of the rice crop based on the Provisional Export and Import Adjustment Law and rice distribution control regulations.

With regards to the gathering of unhulled rice and the handling over of rice controlled by the government-general, an association of surveyors has been established. Concerning the distribution of rice, another association of distributors has been formed. Through these groups, the govern-

ment-general is making efforts to assure the smooth concentration and distribution of rice.

The price of rice is fixed after consultation with the Taiwan rice export and shipment control committee. In regard to the export and shipment of controlled rice, the demand and supply within the island are taken into consideration while consumption control and various other measures are also taken to permit the shipment of the largest possible quantity of rice to Nippon.

The Taiwan rice exports and shipment control enterprise was begun on November 1, 1939, based on the Taiwan rice export and shipment control regulations, with the approval of the 74th session of the Imperial Diet.

Close connection is kept with the Central Government in order to ensure the smooth working of this enterprise, while planned rice production is being effected through the fixing of production goals for certain fixed periods.

The purchase of controlled rice is made through the association of suppliers in each province. Close connection is maintained with the Agriculture Office and matters relative to the sale of rice are left entirely in the hands of the Nippon Rice Co. in order to help the unification of the rice policy in Nippon Proper.

In connection with the enforcement of regulations regarding the restriction of rice polishing, the whitening of rice was restricted to 70 per cent. On the other hand, the use of good rice was prohibited where the need could be met by waste rice, in order to collaborate with the national policy relative to consumption control on rice.

As a measure to insure the smooth concentration and supply of waste rice and crushed rice, official prices for them have beeen fixed. Business relative to the gathering of waste rice and crushed rice in Taiwan is entrusted to the Crushed Rice Distributing Association, which is making efforts for the increase of rice supplies used for food.

The investigation of rice stocks was formerly held twice a year, or on May 1 and November 1, but basic rules of investigation were newly established in November, 1936, to conduct investigations six times a year, or on the first day of March, May, July, August, September, and November. This was enforced in March, 1937.

The grading of rice was enforced in November, 1939, following the promulgation of Taiwan rice export and shipment control ordinance in May, 1939.

The area planted to rice in 1939 was about 320,000 ko, including the first and second crop, and the crops obtained amounted to 4,800,000 koku. The rice shipped from Taiwan in that year was 4,106,712 koku, including unhulled and unpolished rice.

Labor required for rice production.—The unit of labor is that rendered by one man in one hour, and is called man-hour. Labor rendered by women and children is reduced to this basis, that by a woman is calculated at 60 to 70 per cent of that by man, while the work done by a child, at 30 per cent. Table 11 gives the labor requirement for the production of first and second crop of rice.

TABLE 11.—*Labor requirements of one ko of rice in terms of man-hour. Average of 36 farms which were on the average 1.6 ko in area.*

Work items	First crop		Second crop	
	Man	Animal and man	Man	Animal and man
Seed bed	6.28	0.76	1.87	1.39
Land preparation	22.65	18.15	15.08	11.89
Transplanting	11.12	0.09	10.07	0.09
Fertilization	7.06	0.87	4.01	0.06
Weeding	29.52	0.35	23.94	0.19
Irrigation administration	9.59	0.00	6.79	0.00
Pest and disease control	1.05	0.00	1.57	0.00
Making of wind breaks	0.12	0.00	1.80	0.00
Harvesting and threshing	25.81	0.25	27.54	0.53
Total	113.20	20.47	92.67	13.14

Other farm management data.—The following table (Table 12) gives data on five typical farms gathered in 1937. These figures were kindly furnished by Professor Okuda, Chief of the Division of Agricultural Economics of the Faculty of Agriculture of Taihoku Imperial University.

To the information given in Table 12, the following may be added. In Taiwan rice growers are given encouragements by the government and other entities calculated to give them more income and make them more contented citizens. For example, while the price of implements are already comparatively low, the government offers them monetary subsidy to encourage them to buy these implements so they could improve their methods of culture. In Taichu a harrow costs 10 to 15 yen and a rice thresher, 35 yen. To encourage the Taichu growers to till their soil better, they are given subsidy of 10 yen for each harrow purchased. For each thresher, a 25-yen subsidy is given. In Takao Province planters are given a subsidy of 50 per cent of the cost of implements.

Some entities give liberal terms of crop sharing to their tenants. The Terto Sugar Manufacturing Co., for example, give to their tenants 51 per cent of the product instead of 50 per cent only.

Very little data were gathered about cost of labor and farm operations. The cost for converting mountain land with trees and grass into irrigated rice paddy is 700 to 1,400 yen per hectare, while that for converting nonirrigated level land into irrigated, with dikes just high enough to permit carabao to climb over it with one step, is 400 to 800 yen. For transplanting rice, 1.80 yen is paid each day to each transplanter.

TABLE 12.—*Data on farm management for the year 1937 furnished by Professor Okuda of the Faculty of Agriculture of the Taihoku Imperial University.*

	Types of farming				
	(1) A lowland farm in Shinchiku Province	(2) An owner's hog-rice farm in Taichu Province	(3) A rice-hog farm in Shinchiku Province	(4) A tenant's rice-hog farm in Schinchiku Province	(5) A rice-sugar cane, sweet potato-hog farm in Taihoku Province
Members of family	10	11	10	8	12
Male	5	7	4	5	9
Female	5	7	6	3	3
Enraged in agriculture	5	4	6	7	9
Housekeeping	3	4	5	3	4
Children	7	6	3	3	4
Man units	3.5	3.2	2.8	3.0	4.5
Laborer employed for entire year	1	...	...	...	(a)
Land operated lowland rice, owned (ko.)	3.1	1.8	1.8	[b] 2.1	[c] 4.9
Land leased (ko.)	0.4	0.0	...	...	[b] 2.1
Farm yard (ko.)	[d] 0.055	0.035	[e] 0.013	[b] 0.025	...
Forest (ko.)	0.75	...	...	...	[f] 0.02
Total farmed (ko.)	3 555	2.585	...	...	...
Land kept for other purposes (ko.)	0.625	0.1	0.057	0.025	[b] 0.041
Farm yard (ko.))	0.035	0.035	...	...	...
Inventory—					
Price of land at beginning of year (yen)	7.750	12,600.00	0.00	0.00	...
At end (yen)	7.750	12,600.00	0.00	0.00	...
Farm yard (yen)	55	...	...	...	...
Other land—					
At beginning (yen)	...	545.00	...	...	...
At end (yen)	...	545.00	...	...	...
Buildings—					
At beginning (yen)	432.80	206,80	35.75	...	...
At end (yen)	415.84	199.80	33.00	...	...
Improvements—					
At beginning (yen)	44.84	48.20	39.37 inc. tools	57.84	[g] 71.79
At end (yen)	37.93	40.47	34.57	45,93	66.09
Animals—					
At beginning (yen)	308.10	90.40	50.80	171.20	490.00
At end (yen)	311 50	163.70	90.80	177.20	700.00
Crops—					
At beginning (yen)	161.00	179.68	142,99	121.00	336.36
At end (yen)	161.00	181.21	142.99	226.00	555.86
Materials and supplies, etc.—					
At beginning (yen)	32.50	249.00	12.50	26.10	17.35
At end (yen)	129.60	238.00	12.70	90,75	28.35
Total—					
Beginning (yen)	8,784.24	13,919.08	281.99	376.14	915.50
End	8,860.87	13,968.18	314.06	468.88	1,350.30
Land: Borrowed dry land—					
Beginning (yen)	...	...	...	...	2,100 00
End (yen)	...	...	...	...	2,600.00
Land: Leased lowland rice field—					
Beginning	600.00	...	8,640 00	4,410	13,650.00
End	600.00	...	8,640.00	9,240	17,150.00

NOTE: Usually, farmers sell their Horai rice on good prices and buys the cheaper native rice for their consumption.

[a] Given wage and board and lodging 1.

[b] Borrowed. [c] Dryland. [d] Owned. [e] Leased.

[f] Waste land.

[g] Implements.

TABLE 12.—*Data on farm management for the year 1937 furnished by Professor Okuda of the Faculty of Agriculture of the Taihoku Imperial University.*—Continued

	Types of farming				
	(1) A lowland farm in Shinchiku Province	(2) An owner's hog-rice farm in Taichu Province	(3) A rice-hog farm in Shinchiku Province	(4) A tenant's rice-hog farm in Schinchiku Province	(5) A rice-sugar cane, sweet potato-hog farm in Taihoku Province
Others					
Beginning			62.40	50	324.00
End			62.40		324.00
Borrowed, not cash					191.50
Cash—					186.00
Beginning	90.00	20.00	40.00	180.00	176.00
End	25.28	291.24	18.45	58.57	156.00
Debts—					
Beginning	2,600.00		210.00	200	..
End	2,600.00		410.00	500	
Others—					
Beginning			171.50	232.00	
End			168.00	224.90	
Receipts, in yen,—					
Cash for rice (yen)[h]	2,074.00	1,490.35	1,539.80	1,919.32	2,228.50
Sugar cane		60.00			227.00
Sweet potato	53			30.00	289.55
Others	114.27	129.90	87.30	112.54	1,062.65
Total (yen)	2,241.27	1,680.25	1,627.10	2,061.82	3,807.17
Animals—					
Hogs	154.00	90.00	45.00	95	490.00
Other animal products	47.00	24.90	24.70	35	
Other animals	65.00	19.00	16.65	10.50	104.50
Other income			0.05		45.00
Total (yen)	266.00	133.90	86.45	140.50	639.60
Agricultural manufacture—					
Sliced potato		5.00			30.00
Forest		8.00			
Others		0.24			33.00
Grand Total	2,507.27	1,827.39	1,713.50	2,202.32	4,510.30
INVENTORY OF NONAGRICULTURAL PROPERTIES					
Land—					
Beginning		945.00	0.00	50.00	99.00
End		945.00	0.00	50.00	99.00
Buildings—					
Beginning		87.30	28.00	481.40	
End		84.98	27.60	466.38	
Furniture—					
Beginning		235.85	162.81	163.68	279.95
End		218.95	152.91	152.41	258.75
Animals—					
Beginning		3.00	0.00		
End		3.00	0.00		
Supplies and materials—					
Beginning		94.40	41.60	4.00	165.00
End		96.40	54.40	2.00	170.00
Others—					
Beginning					285.00
End					279.00
Total—					
Beginning		1,365.55	232.41	531.40	
End		1,348.33	234.91	516.83	
Depreciation		17.22			
Farm expenses, in yen—					
Buildings	1,696.00	30.40	13.39	34.37	21.75
Implements or improvements	[g] 2,276.00	16.59	17.32	17.10	36.56
Seeds and seedlings	4,633.00	15.03	18.65	63.47	115.20

NOTE: Usually, farmers sell their Horai rice on good prices and buys the cheaper native rice for their consumption.

[h] Improvements.

[g] Implements.

TABLE 12.—*Data on farm management for the year 1937 furnished by Professor Okuda of the Faculty of Agriculture of the Taihoku Imperial University.*—Continued

	Types of farming				
	(1) A lowland farm in Shinchiku Province	(2) An owner's hog-rice farm in Taichu Province	(3) A rice-hog farm in Shinchiku Province	(4) A tenant's rice-hog farm in Schinchiku Province	(5) A rice-sugar cane, sweet potato-hog farm in Taihoku Province
Animals	52.00	15.80	2.45	33.80	145.40
Amortization on animals	18.00	17.00	5.00	30.00	...
Feed	109.30	89.70	20.65	122.25	569.45
Fertilizer	431.02	241.20	308.30	291.00	348.50
Labor	374.00	131.75	92.60	259.10	88.01
Interests on debt	169.00	...	9.54	83.00	...
Taxes and similar burdens	96.64	149.08	7.24	8.77	117.19
Rent	[i] 58.50	...	737.00	794.41	1,132.80
Others	[g] 15.00		1 40	0.06	50.00
Materials for manufacture	...	5.00	...	...	17.50
Medicine	...	...	...	...	15.30
Total	1,400.00	711.55	1,233.54	1,687.27	2,657.36
Income in yen—					
From the property	137.20	56,00	0 00		...
From products other than agriculture	15.00	50.00	3.75	12.00	112.00
Labor income	25 00	34.20	...	20.00	...
Others	23.00	13.00		...	5.00
Total	200 00	118.20	3 75	32.00	117.00
Expenses other than for Agriculture, for utilizing property	16.10	5.08	...	...	...
Labor	0.08	...	...	...	...
Total	16.18	5.08		...	...
Cost of living, in yen—					
Food	[g] 662.50	[g] 490.54	[g] 406.64	[g] 489.60	[g] 761.29
Clothing	60 00	32.00	22.80	50.00	60.00
Housing	12 08	16.12	24.88	63.82	43.15
Recreation	9.04	6.00	2.30	0.00	14.60
Cash	1,085 00	378.32	332.22	722.11	1,033.09
Total	1 226.02	901.14	673.05	883.53	1,702.84
	...	[g] Cash = 74.64	[g] Cash = 134.69	[g] Cash = 443.00	[g] Cash = 273.29

NOTE: Usually, farmers sell their Horai rice on good prices and buys the cheaper native rice for their consumption.

[g] Implements.

[i] Rent of animals.

Government work in the improvement of rice production in Taiwan.—The next table (Table 13) gives figures showing a steady increase in production of rice in Taiwan, particularly in the yield per unit area of land. It will be noticed that in 1903, the year when agricultural and industrial plans began to operate, soon after the pacification drive was completed, the yield per hectare was 14.07 cavans of hulled rice as compared with 19.34 cavans of palay in the Philippines. From that year on the increase in yield was steady and became accelerated beginning with the year 1922. In all years the yield per hectare of Taiwan rice was greater than in the Philippines.

TABLE 13.—*The development of rice crop in the P. I. and Taiwan.*[a] (*Velmonte's*)

Philippines				Formosa			
Year	Area in Ha.	Index	Yield per Ha. cavans (palay)	Area in Ko. 1 Ko = .97 Ha.	Index	Yield per Ko in Koku	Equivalent yield of milled rice in cavans per Ha.
1903	592.766	100	19.34	360,922 (1899)	100	5.69	14.07
1912	1,078,890	182.0	10.77	497,128	137.1	8.17	20.21
1918	1,368,140	230.8	26.16	480.642 (1917)	133.1	10.05	24.86
1922	1,661,430	280.2	26.14	527,096	146.0	10.33	25.55
1927	1,807,060	304.8	27.64	603,058	167.0	11.43	29.31
1932	1,781,630	300.5	20.9	684,928	189.7	13.06	32.31
1939	1,829,987	308.7	[b] 26.2	702,685	194.6	13.60	33.65

[a] Yearbook of the Philippine Islands (1939) 254-255; Bull. of Philippine Statistics 6 Nos. 1-2, 14; Census of the Philippines (1939); the Orient Yearbook (1942) 974.
[b] Lowland rice; Average for all palay = 22.7 cavans.

The ways in which the government accomplished this steady improvement in yield are as follows:

Elimination of poor-yielding rice varieties and purification of adopted varieties.—At the start Taiwan was only growing native varieties. In 1903 there were supposed to be 1,197 of these varieties. In 1906 the government decided to allow the use of only 375 of them and the farmers of each village were further told to grow only 3 varieties which they could select from 375. Meanwhile the government began producing and multiplying seeds of the 3 varieties, the work requiring four years to produce the seed needed by the farmers. After the seed was secured, the farmers were required to plant any one of the 3 varieties. No other varieties were allowed. The rate of seed multiplication was as follows:

1st year	1 Ha. seed bed
2nd year	30 Ha. of field
3rd year	1,000 Ha. of field
4th year	seed available for 30,000 Ha.

From 1903 to 1910, therefore, not only were the varieties reduced and the farmers required to use only 3 varieties but the government was able to distribute purified seed of these varieties.

Briefly the method of purification used was what is generally called pure line selection and consisted of the following steps:

From each variety used, 2,000 plants were picked in the field and reduced to 500 in the laboratory, one head being gotten from each plant in the laboratory.

The seed was planted plant-to-row, hence there were 500 rows, 50 seedlings being planted in each row.

From the 500 lines, 30 were selected in the field at harvest.

The following year, the 30 selected lines were planted in plots and studied carefully. Of these 30 lines, 10 were selected.

The following year, the 10 lines were grown in the original field where the 2,000 plants were previously selected and then after careful observation, only one (1) line was finally selected.

The 1 line selected was multiplied, the work requiring 4 years to supply the seed needed.

Seed of the selected line was given to villages, enough seed being given each village to plant four plots 10 chubo each (1 chubo = 3.3 sq. m.). The seed was given to all villages where the original parent variety was grown previously.

The increase in yield reported due to replacement of inferior native with superior native varieties was 10 to 30 per cent.

According to Dr. T. Tanaka in his lecture at Los Baños, Philippines, there were only 65 rice varieties being grown in 1936 but attempts were then still being made to reduce further the number.

In 1910, to accelerate progress the Government-General adopted the following program of rice improvement (Oshima, 1924):

1. Rice fields were divided into small improvement sections and in each of these sections only such varieties were to be cultivated as were chosen by the "council of experienced farmers and experts" as possessing good quality and high productivity, with the staple of grain resembling that of Japanese rice.

2. The varieties selected were to be improved gradually by mass selection method.

3. New and better varieties were to be bred by pure-line selection of existing promising varieties.

By 1924, the following results of the government work were reported:

1. Decrease in number of rice varieties grown from 1,197 to 390.

2. One kind of rice was formerly cultivated on only 345 hectares. In 1924 one variety could occupy 3,200 hectares.

3. A marked decrease, if not total elimination, of red rice was reported. The resulting improvement in quality resulted in the rise of 6 per cent in average price.

4. Productivity was enhanced especially in case of new varieties bred by pure line selection. Some improved varieties yielded 10 per cent more than the original parents.

The successful introduction and cultivation of Japanese (Horai) rice varieties in Taiwan.—A very important and decisive factor in the improvement of rice production of Taiwan was the successful cultivation of Japanese rice varieties in the Island which was due mainly to the efforts made by Dr. E. Iso, Director of the Government-General Agricultural Research Institute, in the application of agricultural science to the solution of technical problems.

Since the Japanese occupied Taiwan, the Japanese who had to stay in the Island were desirous of eating Japanese rice because they were used to that kind of rice and because, to them at least, it had a better eating quality. In fact they had to import this kind of rice from Japan. On the other hand, since its occupation, Taiwan had been exporting native rice to Japan, but there the Taiwan native rice commanded a lower price than the Japanese rice. Taiwan had been trying to grow Horai rice since the Island's occupation. However, up to 1912, the attempt had been a complete failure.

In that year, on March 31st to be more exact, Dr. E. Iso came to Formosa where he worked as one of the government agricultural experts. A part of his work was to find out how Japanese rice could be grown successfully in Taiwan. At that time, the Japanese varieties matured too early, resulting in very poor yield when grown according to the ordinary method of culture, as when transplanted at the age of some 40 to 60 days. After making extensive and intensive studies, Doctor Iso discovered that by reducing the sojourn of the seedlings in the seedbed from 40 to 60 days to around 20 to 30 days, the Japanese varieties could be grown successfully and good crops could be produced in Taiwan.

This was an epoch-making discovery in the history of rice cultivation in that Island. From that time on, the hectarage of Japanese varieties increased by leaps and bounds. According to Doctor Iso, about the year 1924 the production of rice in Taiwan amounted to 5,000,000 koku approximately, valued at 100 million yen. In 1944 the production is 10,000,000 koku, valued at 230,000,000 yen. The increase is principally due to the successful introduction and culture of Horai rice.

The Taiwan hectarage and production of Horai rices in 1922 and then for a ten-year period, 1930–1939 are given in Table 14, the latter group of data having been copied from 1942–1943 Annuario de la Gran Asia Oriental, Tokyo. The 1922

figure was from the U. S. D. A. Separate No. 1537 (1937) and was given as 400 cho.

TABLE 14.—*Acreage and production of Horai rice in Taiwan*

Year	Area Ha.	Production *Hectoliters*	Per cent of total rice area
1922	396	....	....
1930	609,673	13,493,642	....
1931	625,552	13,493,642	....
1932	658,907	16,140,386	22.5
1933	669,959	15,084,758	....
1934	661,533	16,396,350	....
1935	673,087	16,456,362	....
1936	675,983	17,243,336	53
1937	662,315	16,658,576	....
1938	620,291	17,711,686	....
1939	621,018	16,509,739	91

According to the U. S. D. A. Yearbook separate already cited, the 1932 Horai rice area was 22.5 per cent of total rice area and the production, 25.5 per cent of total rice crop and the 1934 crop represented 61 per cent and the 1935 more than 65 per cent of the total first crop produced in those years.

According to Doctor Iso, 20 years before, he found it very hard to push his project of growing Horai rice in Taiwan. Agriculturists (technical) in Japan were skeptical about it. In Taiwan all including Director Oshima, except Doctor Iso's assistants were against him. When he asked for appropriation for it, he was not given. So, utilizing the cooperation of the farmers who by then already know him and his work, Doctor Iso became successful in his project. One day the Governor General honored him and his work with a visit, and asked to be shown his rice cultures. After he saw them, the Governor was much impressed and from that time on, the opposition to Doctor Iso's work disappeared and everybody was willing to help him.

Breeding, selection and cultivation of superior rice hybrids.—While Japanese rice varieties could be cultivated successfully in Taiwan, they had many defects which should be eliminated if maximum results were to be obtained. For this reason, attempts were made by various government experiment stations not only to select better strains but also to produce superior

hybrids. One of the defects which these stations desired to remove is susceptibility to diseases, particularly to rice blast. Then higher yield also was aimed at. Examples of strains so far selected are Taichu strains numbered up to 13. In the production of hybrids, the most conspicuous results are the Taichu 65 and Taichu 150. Taichu 65 is a cross between two Japanese varieties, Kameji, as female and Sinriki as male parents. Taichu 150 is a hybrid between Taichu 65 and an Italian variety named N. O. 4.

How successful Taichu 65 has been is shown by the following yearly increases in its acreage in Taichu, the data being from the Agricultural Research Institute.

Year	Ha.	Year	Ha.
1920	230	1924	70,827
1921	427	1925	123,206
1922	2,483	1926	102,564
1923	25,078		

It was reported by Dr. T. Tanaka that in 1937, 85 per cent of the rice produced in Taiwan was Taichu 65.

Taiwan rice equivalents furnished by Professor Okuda at the Taihoku Imperial University.

1,000 kin (600 kg.) of Horai paddy gives 457 kg. of hulled rice.
1,000 kin of native paddy gives 446 kg. of hulled rice.
1,000 kin of paddy, Horai gives 412 kg. of war-time polished rice, of native, 402 kg. of polished rice.

From the foregoing figures the following percentages of recovery have been computed:

Hulled rice = 76.2 per cent of Horai palay or 74.3 per cent of native palay.
Polished rice, war-time polishing = 63.7 per cent of Horai palay or 67 per cent of native palay.
Polished rice, war-time polishing = 90.2 per cent of hulled Horai rice or 90.1 per cent of hulled native rice.

1 koku of paddy rice =
- 75 kg. of Horai hulled rice
- 74 kg. of native hulled rice
- 68 kg. of polished Horai rice
- 67 kg. of polished native rice

1 koku of hulled Horai rice weighs 143 kg.
1 koku of hulled native rice weighs 139 kg.
1 koku of hulled Horai rice gives 129 kg. of polished rice.
1 koku of hulled native rice gives 125 kg. of polished rice.
1 koku of polished rice weighs 146 kg. of Horai, or 143 kg. of native.
3.2 koku of rice is obtained from 1000 kin of paddy.

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ILLUSTRATIONS

TEXT FIGURES

A GENERAL REVIEW OF RESEARCH WORK ON PHILIPPINE CROPS WITH SPECIAL REFERENCE TO VEGETABLES [1]

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The establishment and early functions of Government institutions and private entities have in some way or others something to do with agricultural research in these Islands. In 1898, when the Americans arrived in the Philippines, there were only three agricultural stations where some sort of acclimatization, cultural and fertilizer tests were being conducted. The present agricultural promotional research work and agricultural education in this country are the results of the ideas conceived by the first American administrators.

It was apparent at the beginning of the American Administration that the basic industry of the country is agriculture, and for this industry to develop, there should be established in these Islands some real research institutions. At that time, there were no Filipinos trained in scientific agriculture; there were no agricultural schools in the Philippines, and perhaps anywhere in the Tropics. Tropical agriculture was something new to the Americans then.

In 1902 the Bureau of Agriculture was founded, followed by the College of Agriculture, in 1909. With the establishment of these two institutions, the cornerstone of agricultural education including promotional work and agricultural research was laid purely of American pattern. Lawson Scribner was the first director of the Bureau of Agriculture and he, with Taylor, Edwards, Conner, Wester, Jacobson and others, was mainly responsible in laying out the basic foundation of agricultural research and promotional work undertaken by the then Bureau of Agriculture. On the other hand, Dr. Edwin B. Copeland, founder and first dean of the College of Agriculture, together

[1] Read before a special seminar (September, 1946) given by the Technical staff of the Bureau of Plant Industry in honor of the United States Agricultural mission headed by Dr. Lelan E. Call, dean of the School of Agriculture, Kansas State College. Submitted for publication March 24, 1948.

with the late Prof. Charles F. Baker, who succeeded him as dean of the College, may be considered the forerunner of Filipino agricultural scientists.

The Bureau of Science (now Institute of Science) which to a certain extent directly or indirectly undertakes some agricultural research, was a year ahead of the Bureau of Agriculture. As early as 1908 the Bureau of Education established farms and agricultural schools in different parts of the Islands. In 1931 the Bureau of Agriculture was split into the present bureaus of Plant Industry and Animal Industry. At present there are no less than nine Government institutions and a few semigovernment and private entities which in one way or another undertake some kind of agricultural researches.

At the outbreak of World War II there were no less than a dozen experiment stations located in strategic regions with respect to climatic conditions and important crop centers. A good number of these stations were then fairly equipped to undertake important applied research. During the war all these equipments were destroyed, but what we consider as our incalculable loss were the plant immigrants and many stocks—the products of long and diligent research.

At the outset, it was readily recognized by the early American researchers that Philippine crops are rich in varieties and strains. For that matter, it also dawned upon them that the main basis of crop improvement in this country was variety test and selection. These were subsequently followed by introduction, domestication, acclimatization and breeding to accelerate the work on crop improvement. Later, cultural studies including farm management as well as the study and control of pests and diseases were conducted.

Because of its economic importance, rice among few other crops, first received considerable scientific attention. Rice varieties and strains were collected from all over the country and tested and studied in the Bureau's experiment stations. There were no less than 1,000 varieties collected, samples of which were well preserved, but they were all destroyed in the Central Experiment Station of the Bureau of Plant Industry in Manila during the last war.

Jacobson, who may truly be called the father of rice improvement work in this country, started variety test and selection. To facilitate his work on these and other works, he conducted large scale correlation study on rice. The work of Jacobson

was followed up by Apostol, Borja, Camus, Manas and many others and their work led to the isolation and selection of the present standard varieties, namely, Apostol, Guinangang, Macan of different strains, Milagrosa, Sipot, and others for lowland rice culture; and Dumali, Magsanaya, Kinandang Puti, and others, for upland rice culture. Seraup Besar, Kra-Suey, Ramai, Khao-Bai-Sri and Elon-elon are products of introduction work, while Quezon (Raminad Str. 3) and Ramelon had been produced through hybridization and selection. Torres, Unite, and Reyes are credited for this significant contribution. The Quezon rice was primarily bred for yield and quality, but coincidentally it showed a high degree of resistance to stem rot also. These standard varieties individually give a yield of from 50 to over 100 cavans per hectare.

It is believed that with the use of the present standard varieties of rice, our average production per hectare could be hiked from the present 27 cavans to over 40 cavans without any modification in our cultural practices. But so far, only a small percentage of our farmers have availed themselves of these standard varieties. To make research truly fruitful and far reaching, the efforts of our extension service should be geared to the full utilization of these findings.

Results of fertilizer work and other cultural studies show that most of our rice fields give good response to the liberal use of both organic and mineral fertilizers. Thorough preparation of the soil as well as clean culture, proper spacing and rate of seeding, and the liberal application of irrigation water are factors that our researchers have found to substantially increase the yield of rice. All of these results still await big scale application by our farmers.

In sugarcane, introduction work proved highly beneficial to the industry. Varieties like the Badila, Mauritius, and recently P.O.J. 2878 were found to be decidedly better yielders than the native varieties. In breeding work, Alunan and P.S.A. 14 are the outstanding contributions. The Alunan cane, which was produced by the late Anselmo Labrador, of the Bureau of Plant Industry, is well suited to regions of more or less uniform rain distribution, while P.S.A. 14 is better adopted to regions of longer dry season. The history of the improvement of the sugar industry would be incomplete if mention is not made of the fertilizer and other cultural works of Doctor Manuel Roxas and his collaborator and their contribu-

tions on variety test and breeding and the chemistry of sugarcane. The "canalito" system of sugarcane culture, a modified Java system which requires (*a*) deep planting, hence the name; (*b*) good drainage; and (*c*) the liberal use of organic matter supplemented with some commercial fertilizers, is superior to the Hawaiian and native system in point of actual yield. Some two years' trial tests of this method of culture, using the present standard varieties, at the La Carlota Experiment Station, gave an average yield of over 200 piculs per hectare.

The results of introduction work on corn was not so encouraging and profitable. It was a common experience that the first planting of practically any introduced corn was excellent, but the subsequent cultures declined in stand and thriftiness. Preliminary work on the use of F_1 hybrid on native corn has shown some good promise.

On tobacco, the efforts of Paguirigan and Gutierrez gave us the Sumatra and a considerable number of American varieties. Their recent work has further shown the great prospects of the yellow and aromatic cigarette tobaccos, especially in regions where there is a prolonged dry season and where the soil is of average fertility. One of the outstanding results of our selection work on tobacco is the creation of the Simmaba variety, a product of over six years' work of one of our men engaged in tobacco research. This variety is very productive and can be used for filler as well as for batek and for wrapping purposes. Under ideal conditions, it produces very big leaves, the standard ones measuring over 3 feet in length and over 1½ feet in width. Grown under shade, the Simmaba produces wrapper comparable with the finest shade-grown wrapper produced under Georgia, Florida and Connecticut conditions. The shade-grown wrapper industry which was pushed through by Tugade and others under great odds is considered as one of the significant contributions of our tobacco research work, and the expansion of this industry to the annual production of 45,000 kilos worth ₱145,000, at the outbreak of the war gives lie to the common belief that our farmers are slow in adopting improved methods of culture.

With fiber crops, the most important work includes the standardization of abaca varieties which led to the selection of Maguindanao, Bungolanon and Tangongon for Mindanao; Layahon, Alman, and others for the Visayas; Itom and Samina for the Bicolandia; and Putian and Siniboyas for Southern

Luzon. The development of the abaca burlap industry as conceived by Aldaba, and the creation of the Maguindanao × Putian and Putian × Kinalabao abaca hybrids by Garrido which were found to be seemingly resistant to the abaca bunchy top, are other contributions equally significant. On cotton, a number of promising hybrids are in the process of further testing. Ramie, flax, and some jutes are products of fiber introduction work.

Our work on introduction and acclimatization of fruits has also been productive of good results. New industries are being developed as a natural outcome of such findings. Of the more important introductions, mention may be made of (1) the Smooth Cayenne pineapple from Hawaii; (2) the avocado (*Persea americana*) from Central American and Southern United States; (3) the star apple (*Chrysophyllum caimito*) from Tropical America; (4) the different citrus varieties from the United States, China, Siam, and other Oriental countries, such as the Szinkom, King and Ladu mandarins, the Valencia orange, the Siamese pummelo, and Tahite lime; (5) the tiesa (*Lucuma nervosa*) from Cuba; (6) the chico (*Achras sapota*), rambutan (*Nephelium lappaceum*) and Ambon banana from Java; (7) some mango varieties from India and a number of other fruits, such as atemoya (*Anona hybrid*) and Cherimoya (*Anona cherimolia*), grapes (*Vitis* sp.), fig. (*Ficus carica*), apple, peach, Oriental persimmon, strawberry, cantaloupe, watermelon, and others. For the successful culture and propagation of these fruit immigrants credit is due to Wester, Galang et al. P. J. Wester, one of the greatest explorers in the Tropics, is credited with the greater number of our exotic plants, and the world fame of the Lamao Experiment Station as one of the richest arboreta in the Tropics for both tropical and subtropical fruits is mainly due to him. Unfortunately, the greater portion of this collection was destroyed during the war.

One happy feature of our introduction work on fruits is that most of the early introductions were in the form of seeds, and those that fruited first were also propagated by seeds. As an ultimate result we now have trees differing very widely in pomological characteristics. These trees now afford us rich materials for improvement. The *Persea americana* is a good example. There are now hundreds of avocado varieties and strains, and a number of them are exceptionally superior in

quality and in yield. But one of the most important features in the variation of this fruit is its seasonal fruiting habit. It is predicted that in a couple of years, we will have in the Philippines this highly nutritious fruit practically throughout the year.

In the case of native fruits, our work on domestication and selection is bearing some tangible results in the isolation of superior strains both in yield and quality. Mention may be made of mango (*Mangifera indica*), lanson (*Lansium domesticum*), tamarind (*Tamarindus indica*), santol (*Sandoricum koetjape*), native citrus, pili nut (*Canarium ovatum*), chico, ates (*Anona squamosa*), durian (*Durio zibethinus*), cashew (*Anacardium occidentale*), and others. Cashew, duhat (*Eugenia cumini*) and bignay (*Antidesma bunius*) have been found as excellent raw materials for the manufacture of high quality fruit wines. Tamarind, santol and durian fruits when processed will yield products highly demanded in temperate countries. The exploratory work of Adriano and his coworkers on the utilization and processing of native fruits has shown great possibilities.

The work of the Bureau of Plant Industry on asexual propagation of fruit trees and on orchard management as worked out by De Leon and others is of tremendous importance in the development of our fruit industry and in the maintenance and conservation of soil and its. fertility. Asexual propagation has not only made the tree bear fruits much earlier, but it enables the propagation of uniform fruits in unlimited numbers.

Introduction work also saved the once flourishing coffee industry. With more extensive planting of *Coffea robusta* and *Coffea excelsa,* the Philippines will be self-sufficient in this commodity in due time. Cacao (*Theobroma cacao*) has also a good future in this country if and when the pests attacking it are properly put under control.

The rubber and the cinchona industries are also products of introduction. What little work we have accomplished so far on rubber is credited to Galang and Luistro. The elaborate work on cinchona is due to the disinterested and untiring effort of Mr. Arthur Fischer, former Director of Forestry. Many spices as well as insecticidal and medicinal plants have been successfully introduced and tested in this country; the future of these plants is great.

Vegetable crops have been the subject of no lesser effort on research work. Their improvement both in quality and number means better nutrition for our people. The beans because of their nutritional value and their unique role in crop rotation received considerable research attention and will continue to do so. Some improvements have been made on native beans, and such crops as the cowpea (*Vigna sinensis*), sitao (*Vigna sinensis* var. *sesquipedalis*), kidney bean (*Phaseolus vulgaris*) and soybean (*Glycina max*) have been successfully introduced.

Introduction work on soybeans was started as early as 1911, but it was only towards the middle of the thirties that some promising results were obtained. Of the over two hundred varieties introduced from China, Japan, the United States including Hawaii and India, only four have been seeded out as adapted to certain regions with yields varying from 15 to 30 cavans per hectare. Hybridization work started by Unite and his coworkers yielded many promising strains, and some of these will ultimately replace the introduced varieties. While some authorities claim that the soybean has a definite inoculant distinct from those of other legumes, Agati of the Pahtology Section found that some strains isolated from soybean nodules in our early cultures were distinctly superior to the pure inoculant imported from Illinois. The successful use of soybean inoculant became one of the features of extension service, but unfortunately it was cut short by the ravages of war when everything was either destroyed or lost.

With onions, the first successful attempt on its acclimatization was made in 1921, but the raising of onion on a commercial scale was not realized until 1931 when it was discovered that the Bermuda onion could be grown locally. So impressive was the result that farmers in Nueva Ecija, Batangas, the Ilocos and other provinces went seriously into its culture. Further introduction work yielded the Red Globe from India, a more pungent variety but with a storing quality distinctly superior to that of the Yellow Bermuda. Results of studies on methods of culture, the use of fertilizers and irrigation water, so far obtained locally, when applied will increase production per unit area and will greatly improve the quality of the product. Already, onion is now being used as a profitable rotation crop with both the upland and lowland rice. Exploratory work too has shown great possibility of

producing onion seeds for commercial planting. Temperature and latitude are factors that play an important role in onion seed production.

In the case of the cole crops which in this country are best represented by cabbage and cauliflower, their cultures date back from the later part of the Spanish regime, mostly in regions of medium and high altitudes. With the advent of American sovereignty in this country, many trial tests were made in different parts of the Islands mostly by American teachers, especially those assigned in farm and agricultural schools. The first systematic introduction and acclimatization work on these crops were made by the Bureau of Plant Industry in its different experiment stations.

Both cabbage and cauliflower have been found to be adapted to commercial growing practically in all places of the Philippines, but they do better at higher altitude and in regions of greater latitude. In the cauliflower the limiting factor is more on variety and season rather than on other factors. Cabbage and cauliflower thrive best during the cool months of the year. Of the more important cabbage varieties found suitable for commercial planting in these Islands may be mentioned Shanghai for rainy season culture, and Succession, Allhead Early, Flat Dutch, Surehead, Enkhuizen Glory, and Charleston Kakefield during the general vegetable season. In the case of cauliflower, Early Patna and Early Market for the lowland and Snowball for medium and high altitudes are suitable.

Research work on Irish potato has shown that this crop can be grown successfully in regions with an elevation of from 1,000 to 5,000 feet above sea level. The best crops are obtained during the cool months of the year. Among several varieties so far tested under local conditions May Queen, Glasgow Favorite, Japanese white, and Burbank are some of the best.

Other vegetables that have been found to grow well under local conditions include American tomato, sweet pepper, carrots, beets, celery, lettuce, pechay, radish, mustard, endive, chard, Spinach, leak, okra, chayote, peas, sweet corn, cucumber, and a few others.

One of the most vital problems that confront the Filipino farmer is how to store his seed for the next planting season. He has to store his seed because there are practically no seed houses here like in America and other countries. And

it is his common experience that seed thus stored for the next season does not keep its viability long. This is more so with seeds imported from temperate countries which upon arrival here are subject to two or three factors that are conducive to the rapid deterioration of seeds; namely, high temperature, high humidity and the presence of some weevils.

Research efforts along this line led to the evolvement of a simple yet practical method of seed storage. This method simply calls for a thorough drying of the seed soon after harvesting and its subsequent storage in air-tight containers. Trials of this method of seed storage with imported vegetable seeds from temperate countries proved both practical and efficient. A piece of work started in 1924 to determine the longevity of vegetables and farm crop seeds revealed great variation in their longevity. Oily seeds like peanut and soybean lasted only over two years; rice, corn and sorghum over four years; and tight coated seeds like some beans such as *Phaseolus aureus* and *Phaseolus calcaratus* about 16 years in storage, were still strongly viable at the outbreak of World War II. Trial tests of the vitality of some seeds under different lengths of storage, as expressed in terms of seed and vegetative production, revealed that the seeds in question seem to undergo a certain degree of aging before they reach that stage when they have the full expression of their productive power. In the case of *Phaseolus aureus*, it was found that a 10-year old seed was more vital than a one-month old seed of the same variety and strain.

This general review would be incomplete if no mention is made of our work on the study of pests and diseases of Philippine crops and their control. In this connection, it may be stated that the problems connected with the study of plant pests and diseases and their control are far more complex in the Philippines than in the United States and other temperate countries, where winter serves as a natural barrier in the rapid multiplication and spread of crop pests and diseases.

The study alone of the life cycle of the most important insect pests of rice, corn, citrus, coconut, many of the fruit trees and vegetable crops and of their control is a significant contribution of the Bureau. The reduction to the minimum of locust infestation, the swift manner in which the coconut leaf miner, which once threatened the coconut industry, was

put under control, the effective and practical control of army worms and numerous pests of vegetables and other crops are directly traceable to the research efforts and regulatory activities of the Bureau of Plant Industry as worked out by Merino, Otanes and others. Concoctions of new insecticides and the successful use of the standard ones were made possible to suit local conditions only after considerable tests and trials have been made.

The problems of pests and their control were also the problems in the study of plant diseases and their control. Of the more important diseases studied mention may be made of the coconut bud rot, the bunchy top of abaca, rice-stem rot, rice-stunt diseases, coffee rust, sugarcane Fiji, various citrus diseases, mosaic diseases, on tobacco and other crops and lately a number of other virus diseases on various crops. Such workers as Clara, Reyes, Agati, Fajardo, and others have brought the study of applied plant pathology a long way in this country. The isolation of native bacterial inoculant for various field beans, notably the soybean which has already been mentioned elsewhere in this paper is considered significant. Lastly, a Fungus and Host Index to the Presently Known Fungi in the Philippines has been compiled in book form by Dr. N. G. Teodoro, formerly of the Bureau of Plant Industry.

These are the salient accomplishments of the Bureau of Plant Industry along agricultural research during the brief period of 45 years of Filipino tutorship in scientific agriculture. The results so far obtained are indeed modest, but if our farmers avail themselves of the useful information accumulated, such results, it is hoped, would go a long way towards the improvement and promotion of Philippine agriculture.

A REVIEW OF WRAPPER TOBACCO EXPERIMENTS AND INVESTIGATIONS IN THE PHILIPPINES BY THE BUREAU OF PLANT INDUSTRY

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INTRODUCTION

There are ever-changing fads in smoking, just as in clothes, foods, amusement, and luxuries the people enjoy from time to time. Before the nineties the discriminating cigar smokers wanted rich, brown and dark-wrapped cigars, which are stronger in taste than those demanded by present-day addicts. The prevailing fashion now is for mild cigars wrapped with fine silky textured leaf from olive (fallow) to very light brown colors, as the appearance indicates the quality of the cigars. With the early demands, the Philippines was self-supporting in her cigar industry, but with the imposition of modern desires, this industry lacks the desired wrappers. The famous Havanas (Cuban cigars) are made purely from Cuban materials, from the same *Havanensis* variety. Hence, the control of production is within the country and the ensemble is perfect. In order to satisfy world demand in Manilas (Philippine cigars), the country has perforce to import the famous Sumatra cigar wrapper leaf, which industry was developed by the Dutch in the middle sixties, the Georgia wrappers of more recent development and, occasionally, the American shade-grown wrappers of still much later development.

The grave defect of the Philippine tobacco industry was the utter disregard of the world trends, due to deep-rooted hold on the industry by very conservative tobacco interests. It is a truism in all agricultural pursuits of a country for the farmers to grow what is wanted locally of them. Local factories are no longer catering to the local and Spanish tobacco demands only, for Philippine cigars have become cosmopolitan by virtue of their world-wide acceptance. The net result of this disregard of world trends, which places the tobacco industry out of tune with the times, was that the country turned a great and sudden somersault from that of 100 per cent tobacco ex-

porter to that of a large tobacco importer of manufactured tobacco products and raw materials in the form of cigar wrapper leaf. The import of cigar wrapped leaf reached a peak of some ₱2,000,000 in 1924; that of Virginia yellow leaf is worth around ₱800,000 yearly.[1] While the wrapper constitutes but a small fraction of the cigar, it costs very much more than the filler used. A kilo of first-class fallow-colored Sumatra costs ₱30, whereas the best Philippine filler costs only from ₱0.30 to ₱0.40 per kilo.

The defunct Bureau of Agriculture, superseded later by the Bureau of Plant Industry, realized this grave defect of the tobacco industry, and accordingly, started experiments on wrapper growing as early as 1903, but in a more dogged and persistent way since 1916, when with the creation of the Tobacco Inspection Service through Act 2613 as amended, 30 per cent of the collection was yearly allotted (5) to the improvement of leaf tobacco.

The initial work on the production of cigar wrapper and even of the aromatic cigarette tobacco was handicapped for lack of these types, but only the filler type, which was introduced in the later part of the sixteenth century during the Spanish regime.

With the organization of the Bureau of Plant Industry, there was created the Tobacco Research Section, financed by Act 2613 under the Department of Finance, but the direction of the work falls within the jurisdiction of the Bureau of Plant Industry under the Department of Agriculture and Natural Resources. This section specialized on tobacco alone, one of the five major crops of the country. Due to this crop specialization, some members of the section specialized further by working on one of the types—filler, wrapper, and aromatic cigarette tobacco—while a few others took up general tobacco work and these men became useful as general extension tobacco specialists.

The Tobacco Research Section, confining its researches and investigations on tobacco alone, has accomplished much and the accomplishment compares favorably with the results of research on any other single major crop of the country. These results have also helped foster specialization on the major crops as well as minor crops that are forging ahead in importance in this country.

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[1] The importation including cigarettes amounted to ₱45,000,000 in 1946.

This review deals with the work on the cigar wrapper type only. The local production of cigar wrappers should arouse keen interest at this time, because the Sumatra and Java wrapper industry, the source of part of our wrapper supply, is completely disorganized as a result of the World War II and the rebellion of the Indonesians. The Georgia wrapper production has also suffered because of the demands of labor for the American war effort and other priorities and the present dearth of transportation facilities. It will take some years be fore wrapper leaf can be imported into this country from the sources of supply. Meanwhile, our cigar factories, which have recently been rehabilitated, would not be able to export the kind of cigars desired by former customer countries. It is therefore urgent to produce the imported wrapper locally with a view to making the country self-sufficient in raw material requirements of its oldest industry.

By accident of work and location and mindful of the world tobacco trends, the writer had taken special interest in wrapper work since 1918 and had organized successively, as a natural result of a little trial in the 1917–18 season, the Pikit and Sarunayan Tobacco Experiment Stations, which pioneered in the research on open-grown cigar wrapper leaf. In 1922 the Pikit Station(1) made the discovery that open-grown Sumatra wrappers, equal to the imported genuine Sumatra leaf, could be produced in some regions of Southern Mindanao. Later, as chief of the Tobacco Research Section, he helped organize the work of the Kidapawan Wrapper Tobacco Production Station, Cotabato. These tobacco stations were dedicated to the research on cigar wrapper and its production. In its commercial culture, the Kidapawan Station was following the Sumatra plantation method of culture with very gratifying results. Unfortunately, during the war, the Japanese Army completely stripped the station of all its buildings, equipment, supplies and materials. Owing to the keen interest manifested in wrapper production at this time, this station should be rehabilitated.

In order to enlarge his experience the writer accepted work in 1928–1930 in the Tabacalera, where a complete importation of Dutch experts, Javanese and Chinese expert planters and coolies from Sumatra, Java, and China, were made in order to produce the Sumatra cigar wrapper leaf by following in exact details the Sumatra plantation method of culture. The best Sumatra

seeds, the Baker Sumatra, and the Bx-27 and Ax-11 hybrids of the Sarunayan station were supplied to this plantation. The imported Vorstenlanden, Java, and American Sumatra seeds did not give so good results as the local selections and hybrids.

A very pertinent question may be asked by the public. With the accumulated results of wrapper tobacco research for over three decades, why are there not many growers going into wrapper production? The present reviewer gave the answer as early as 1927(1) after a review of the cooperative farmers' work in growing wrappers as follows:

> The writer entertains more hope for large production under the plantation system of management than among small farmers for tobacco wrapper that will command as good prices as obtained by the planters of the best wrapper regions of the world for their product, because of the very nature of the work, which requires attention to many details; the fact that fermentation of the cured leaves cannot be properly done with a small quantity containing many grades; that classifying leaves into many grades as required by the factory can be more profitably done with large quantities; and that tobacco varies greatly with cultural treatments, soil, and time of planting.
>
> Good tobacco wrapper should, however, be produced also in a region following the central system; the individual small farmers growing and curing their tobacco with due attention to the desires and requisites of the central, which buys, ferments, classifies, packs, and disposes of the finished leaf,—the combined production of the central and many neighboring small farms.

The following enumeration of the results of research and investigations on wrapper tobacco gives within the scope of a single article a brief account of what has been accomplished on the wrapper tobacco type only by the Tobacco Research Section on a new industry the product of which is needed for local factories as well as for export.

The reviewer has not accepted unqualifiedly all the results of the experiments, if there were some errors in the research approach or if the results were contrary to those obtained on large commercial plantings. Being a pioneer in this work and having widened his experience in a commercial wrapper plantation for the production of Sumatra wrapper and having devoted many years to the subject, he believes he is qualified to render his views on the experiment, the results of which are either unreliable or would give contrary results on repetition with the approved method of conducting field experiments.

EXPERIMENTS AND INVESTIGATIONS

ACCLIMATIZATION TESTS

Gutierrez (1) summarizes the work for six years, 1920 to 1925, as follows:

During the past six years Pikit and Sarunayan between them received, originated, and cultured 37 varieties and strains of wrapper and filler tobacco from different parts of the world, including native varieties mostly from the Cagayan Valley. Five of these are hybrid varieties originated at the station in 1922.

In this work it was found that tobacco seed received direct from tropical lands gave good results from the very first planting; varieties from cold countries either gave very indifferent results indefinitely or adapted themselves to the new environment rather slowly, with the notable exception of the Florida Sumatra and the Sumatra American-grown. Of wrapper varieties remarkable results were obtained with the following: Florida Sumatra (P. I. 8714), Baker Sumatra (P. I. 8587), S. P. No. 1 (P. I. 8293), S. P. No. 2 (P. I. 8294), Ax-hybrid (P. I. 8592), Bx-hybrid (P. I. 8591), Cx-hybrid (P. I. 8590), Dx-hybrid (P. I. 8589), Ex-hybrid (P. I. 8588), and Sumatra American-grown.

The wrapper leaves produced in the years 1922, 1924 and the beginning of 1926, which received favorable comments, came from these varieties, especially the first six in the list. The successful results obtained with these varieties in the production of wrapper tobacco should be considered as the most valuable contribution of the Sarunayan (formerly Pikit) Tobacco Experiment Station for the improvement of Philippine tobacco.

In acclimatization tests (3) at the Dammao Tobacco Station, Gamu, Isabela, in 1923, using Florida Sumatra, Sumatra, Connecticut Havana and Havana, only Florida Sumatra showed normal performance although rather markedly susceptible to mosaic.

In the acclimatization trials (4) of 36 foreign varieties at the Ilagan Tobacco Experiment Station, Isabela, including the wrapper varieties Stewart Cuban and Connecticut Havana, it was found that these varieties did not prove as good yielders as the standard varieties of the station.

VARIETY TESTS

In variety tests (1) conducted at the Pikit and Sarunayan Tobacco Experiment Stations four varieties and two hybrids were found the best. These varieties and hybrids, together with their performance, are as follows:

Baker Sumatra (P. I. 8587).—The plants attain the same development as in Sumatra, having an average height of 2.1 meters, 30 erect leaves, 42 cm. long and 27 cm. broad.

Grown in the open, it gives an average yield of 1,008 kilos per hectare with 342 kilos, or 34 per cent, wrappers.

Under young coconuts or *Tephrosia candida* as partial shade plants, the average yield per hectare is 658 kilos, 243 kilos of which, or 37 per cent, are wrapper tobacco. The yield in the shade is less than in the open, because the leaves, being thinner, are lighter.

The leaves produced from this variety possess the same characteristics as the genuine Sumatran standard wrapper leaves. The station has done more work on this variety and yearly devotes more ground to it than to any other variety.

Florida Sumatra (P. I. 8714).—The plants are very stocky with large and broad, close-set elliptic leaves with blunt tips. The leaves being almost elliptical in shape have the form desirable for wrappers. The fermented leaves have an agreeable aroma. This is, therefore, eminently a dual-purpose variety, i.e. besides producing wrapper leaves, the thick leaves unfit for wrapper are excellent for filler of high-priced cigars and for blending for aromatic cigarettes.

Cultured in the open, this variety gives an average yield of 1,125 kilos per hectare, 304 kilos of which, or 27 per cent, are wrappers.

Under partial shade, the average yield is 1,003 kilos, 340 kilos, or 33 per cent, of which are wrappers.

S. P. No. 1 (P. I. 8293).—This strain is similar to Baker Sumatra. The plants attain an average height of 2 m. have up to 30 leaves with a breadth index of 60.8 per cent, the size being 41 cm. long and 27 cm. broad.

In open cultures, this strain gives an average yield of 1,197 kilos, 236 kilos or 22 per cent are wrappers.

Under *Tephrosia candida*, it gives a yield of 800 kilos, 264 kilos or 33 per cent, are wrappers.

S. P. No. 2 (8294).—This strain is a standard wrapper variety. The plants attain an average height of 2.3 m. with 31 leaves with a breadth index of 60.9 per cent. The leaf measures 40 cm. long and 24 cm. broad.

In open cultures, this strain gives an average yield of 1,122 kilos per hectare, 195 kilos or 16.5 per cent are suitable for wrappers.

Under *Tephrosia candida*, it yields 707 kilos per hectare, 172 kilos or 28 per cent, are wrapper leaves.

Ax-hybrid (P. I. 8592).—The F_2 gave a yield of 1,786 kilos per hectare, 320 kilos or 17.4 per cent are suitable for wrappers. After many years only Ax-11 and Ax-16 strains were selected.

Bx-hybrid (P. I. 8591).—The F_2 gave a yield of 1,600 kilos per hectare, 352 kilos or 22.1 per cent were wrappers.

Under *Tephrosia candida*, it gave a yield of 635 kilos, or 27 per cent were wrapper leaves.

Only Bx–27 strain was retained.

In tests made at the Ilagan Station (3) in wrapper yield Baker Sumatra led with 46 per cent, followed by S. P. No. 1 with 38 per cent, and S. P. No. 2 with 34 per cent, Havanensis yielded 24 per cent and Florida Sumatra 20 per cent. In total yield, Florida Sumatra came out first with 1,840 kilos; Baker Sumatra, 1,629 kilos; S. P. No. 1, 1,301 kilos; and Havanensis, 1,134.

The high yields registered by the above wrapper varieties, which equaled the yields of native filler varieties tested in the same season, show that the leaves produced were rather thick and not so fine as first-class wrappers.

The yields of the three varieties used in the test at the Ilagan Station (3) in 1926 were Sumatra 1,240 kilos of leaf tobacco with 40 per cent wrapper to the hectare; Florida Sumatra 1,333 kilos with 30 per cent wrapper; and Havanensis 776 kilos with 10 per cent wrapper.

Among the varieties tested at the Ilagan Station in 1928 (5) Sumatra led with 35 per cent wrapper, followed by Havanensis with 15 per cent, and Florida Sumatra with 10 per cent.

At the Ilagan Station (6) the varieties Vizcaya, Ilagan Sumatra, Baker Sumatra, and Florida Sumatra yield 476, 325, 281, and 179 kilos of leaf tobacco per hectare, respectively. These results were abnormally low in contrast with previous results.

In most of the above tests in two distinct regions of the country, the Baker Sumatra was found the best wrapper variety. Large commercial cultures of this variety at Hacienda San Antonio, Ilagan, Isabela, confirmed fully this finding.

CULTURAL TESTS

Seedbed methods: Pricked vs. unpricked seedlings.—Pricked seedlings (5) carefully pulled up with earth and set in 40 by 90 centimeter holes and ridged up by alternate cultivation with two types of cultivators produced 1,207.67 kilos of cured leaf with 29.93 per cent, or 361.5 kilos, of wrappers per hectare. The unpricked seedlings given similar treatment yielded 1,413.51 kilos of cured leaf tobacco with 17.8 per cent, or 251.6 kilos, of wrapper. Hence a difference of 109.9 kilos of wrapper tobacco in favor of pricked seedlings.

Paguirigan, Peralta, and Casupang (7) made in 1935–36 at the Los Baños Economic Garden, Laguna, comparative tests on the effect of transplanting pricked and unpricked seedlings of different ages upon growth and yield of the wrapper, cigar filler, and aromatic cigarette types. They state:

> Different ages of pricked and unpricked seedlings ranging from 44 to 86 days old from the date of sowing were used. The pricked seedlings were spaced 10 cm. apart on the seedbed, and the unpricked seedlings were spaced on the average, 6.5 cm. apart on the seedbed. The rate of sowing was 0.10 gm. per square meter.
>
> Seedlings whose largest leaf measured between 10 to 18 cm. long gave the best percentage of recovery. The minimum size, best for transplanting required 51 days for the unpricked and 58 days when (pricked) seed-

lings. Pricked seedlings at this age (51 days old) were found still below the average best size of planting materials. There was no advantage gained as regards time of pricking seedlings.

Under normal conditions, seeds of late maturing varieties, like Simmaba, required at least 58 days time on the seedbed before the best size of planting materials could be developed.

The best stands of tobacco plants were obtained from seedlings transplanted at ages of 51 and 65 days.

Of the early maturing varieties of tobacco like Ilagan Sumatra, etc., unpricked seedlings transplanted at the age of 51 days produced the heaviest yield. The pricked 58-day-old planting materials produced the second heaviest yield.

Of the pricked and unpricked seedlings of the late maturing variety, like Simmaba, the 58-day-old produced the highest yield.

When transplanting on the field was delayed (as late as 72 days), pricked planting materials produced yield better than that of unpricked plants.

On the whole, the authors disparage pricking tobacco seedlings with a discussion based on the light of physiology or ecology of the plant and on the results obtained. Within the limitations of their experimental methods, the conclusions of the authors were unwarranted as the pricked seedlings of the Simmaba showed superiority in leaf product and in yield, from 58 days up. Their result on the Simmaba apparently escaped their notice.

The primordial object in pricking seedlings growing thickly in the seedbed is to give sufficient space, 5 cm. to 7 cm. each way, in order to insure uniform and rapid development of the young plants for the production of wrapper leaves. In the Ilagan station tests (5) just described, while the pricked seedlings registered lower yields than the unpricked, the percentage of wrapper leaves was greater. The Los Baños test used only yield as criterion including the wrapper variety Ilagan Sumatra. The Pikit and Sarunayan stations adopted the pricking method in the intensive method of culture for the production of wrapper leaves.(1)

A practical illustration of the doubts on the merit of pricking tobacco seedlings came to the attention of the writer when at Hacienda San Antonio this method was tried and failed completely ("fracaso completo"). This failure was discovered to be due to faulty technic, as when it was retried by an experienced know-how, the pricked seedlings not only outgrew the unpricked, but were harvested one week ahead.

The technic used was similar to the Pikit station method,[8] which in broad details was as follows:

Generally, the Station pricks the small seedlings to fresh beds. When the seedlings that have been thickly sown are 15 to 25 days old, they are drawn from the seedbeds and are planted 7 cm. apart each way in new beds by women and children. These beds need not have the soil sterilized. These pricking beds are covered with slats or talahib stems woven with bejuco, resting on level framework of bamboo. The covers admit half light and can be rolled at will, if it would be necessary to give full sunlight and during the watering of the seedlings by sprinklers.

In this connection, the technic of Paguirigan et al. on the above experiments was not entirely devoid of faults. Why give early and late maturing varieties 28 days before pricking? Why adopt a weekly interval of sowing and pricking for early especially and late maturing varieties?

After all that is done and stated, both the rate of seedling of 0.10 gram and 0.20 gram per square meter and the distance of unpricked seedlings of 6.5 centimeters comparisons were unwarranted and pricking process was entirely superfluous.

Seedlings with or without soil.—Seedlings [5] with soil and unbroken roots planted in furrows yielded 1,041.65 kilos of cured leaf per hectare, 303.5 kilos of which, or 29.14 per cent, were wrapper leaves, while those seedlings without soil produced 1,571.03 kilos, 216.8 kilos of which, or 13.8 per cent, were wrapper—a difference of 86.7 kilos of wrapper per hectare in favor of the seedlings with soil among the roots.

Seasonal and off-season tests.—"As a result of the work[1] on these experiments at the Pikit station, it was found in 1922 and corroborated by the tests made in succeeding seasons that sowing seedbeds about the beginning of October, and transplanting the seedlings to the fields after the middle of November, gave better results in the quantity and quality of leaves for wrappers than earlier or later plantings, under normal weather conditions. Some of the outstanding facts discovered in our seasonal planting tests may be briefly stated.

"The plants must grow rapidly. For the best results, 144 days from sowing to maturity is the proper period.

"There must be a gradual diminution of rainfall from seedling to maturity stages. The ideal requirements of rainfall lie within the following limits: Seedlings stage, 200–280 millimeters; growing stage, 100–200 mm.; maturing stage, 50–100 mm."

Off-season and seasonal plantings at the Pikit Station(2) were carried on through two sets of experiments: the first set was planted in April and May for off-season; the second, in September and in October. Taking the variety Baker Sumatra used throughout these tests, the results were as follows:

April planting was a failure due to severe attack of stem borers.

May planting gave a large production and a large percentage of wrapper, giving a total of 1,400 kilos per hectare with 618.3 kilos, or 44.2 per cent, wrappers.

The regular season plantings in September and October showed good growths.

The rainfall in Pikit in 1922 was as follows:

	Millimeters.
January	119.5
February	68.3
March	217.8
April	275.5
May	287.7
June	213.4
July	145.9
August	91.7
September	66.3
October	263.8
November	182.2
December	60.6
Total	1,992.7

In 1928 at the Ilagan Station,(5) the November Sumatra crop gave the best percentage of wrapper (15 per cent), although yielding only 1,412 kilos per hectare. The January crop gave 1,488 kilos with 8 per cent wrappers. The March and May crops were failures.

The November results at Ilagan confirm those obtained at Pikit and Sarunayan stations, although these two regions are widely separated. Since Sumatra is an early strain, requiring more moisture than other types, it should be planted a month or two earlier than the general tobacco plantings in the Cagayan Valley and other cigar-filler tobacco regions.

Spacing experiments.—Paguirigan and Hernandez,(9) the latter under the supervision of the writer, studied the effect of distances of planting in the production of cigar wrapper leaves. The varieties Baker Sumatra and Florida Sumatra were used, with five sets of spacings tried, namely, 100 $\times$ 50 centimeters,

90 × 50 centimeters, 80 × 50 centimeters, 70 × 50 centimeters, 80 × 40 centimeters.

The following noteworthy facts were established for the two varieties under climatic and soil conditions typical of the Cotabato Valley:

1. Of the two varieties tested, the Baker Sumatra is more adaptable in the production of wrapper than Florida Sumatra.
2. The best distance combination for Baker Sumatra is either 80 x 50 cm. or 80 x 40 cm.
3. While Florida Sumatra does not produce as great a percentage of wrappers as the Baker Sumatra, its production is nevertheless quite fair when planted 90 x 50 cm.

At the Ilagan Station,(10) four distance combinations were tried, using only Philippine Sumatra. The Sumatra method setting out the plants 50 centimeters apart in alternate rows of 80 centimeters and 50 centimeters gave the highest yield, 1,690 kilos per hectare of which 35 per cent was suitable for wrappers. Planting 80 by 50 centimeters gave 1,412.2 kilos of which 15 per cent were wrapper tobacco, while 80 by 60 centimeters gave 1,350 kilos with 7 per cent wrapper. The plot with 80 by 40 centimeters was badly worm-eaten and no yield was taken.

Bed versus ridge system.—Comparing the bed and ridge methods of planting (5) with Sumatra, the percentage of wrappers obtained were 22.47 and 8.42, respectively, or 18 per cent in favor of the bed method.

Mulching tests.—The Ilagan Station (5) found that wild patani stems used as mulch compared with earth and tarred paper mulches produced the tallest plants, averaged the most standard leaves, and produced the highest yield, 1,616 kilos of marketable leaf tobacco per hectare, with 31 per cent wrapper.

Fertilizer tests.—Pot fertilizer tests were conducted at the Ilagan station (6) in 1928, using the triangular system in 8⅓ per cent stages with 91 possible combinations, but only 16 triple combinations were regularly scattered in the system. Plots 220 and 230 with an application of 100 kilos phosphoric anhydride produced the biggest leaves.

In another fertilizer experiment in the same station,(10) ammonium sulphate, superphosphate, and sulphate of potash, applied singly, double or treble combinations in 42 plots of 1/80 hectare each were used. The best yield was obtained from Plot 34 with the application of 75 kilos of sulphate of potash per

hectare. Apparently, yield was the only desideratum in these tests, even if a wrapper variety, the Philippine Sumatra, was used. Were it in percentage of wrapper, perhaps another plot with other fertilizers with lower yield but greater wrapper percentage, due to light and fine texture, would have been chosen as the best.

Partial shade experiments.—"At Pikit (1) experiments in planting tobacco under natural partial shade, using young coconut trees, the common permanent crop in the Cotabato Valley and *Tephrosia candida* have been tried. The varieties used in these tests were Baker Sumatra, Florida Sumatra, S. P. No. 1, S. P. No. 2, and Bx-hybrid." These tests were continued at Sarunayan, using the *Tephrosia* with the same trend of results. From these varieties, the greater percentage of the leaves was wrapper tobacco. In the discussion under variety tests, the results under shade of these varieties were given.

To check the results in the shade plantings, an area was planted to the same varieties in the open under identical soil conditions and culture. The results in the open planting showed conclusively that but for a trifling difference in fineness, fine wrappers can be produced at Pikit and at Sarunayan in the Cotabato Valley without shade.

Conditions for growing tobacco wrapper in the Cotabato Valley may thus be favorably compared with those in Sumatra, where this tobacco is produced without shade.

By using the standard cheesecloth, the "saguran" and talahib stalks for shading the native variety Vizcaya, the following results were obtained at the Ilagan station in 1931.(6)

TABLE 1.—*Results obtained with the use of cheesecloth, saguran, and talahib stalks for shading the variety Vizcaya.*

Shading material	Yield per hectare in kilos. Total	Wrappers	Wrappers
	Kg.	*Kg.*	*Per cent.*
Check (not shaded)	487.3	75.3	21.7 (15.7)
Cheesecloth	523.0	124.0	23.7
Saguran	702.1	339.6	47.0 (48.2)
Talahib	352.5	191.7	54.4

While the "saguran" shade produced a little smaller percentage of wrappers than the "talahib", it turned out the largest size and the highest quality of wrapper leaves per hectare, followed by talahib, and lastly by the cheesecloth.

The varieties Ilagan Sumatra, Baker Sumatra and Florida Sumatra, were planted separately between rows of *Tephrosia candida* and yielded 17.9, 25, and 14 per cent, respectively, of wrapper leaves. The experiment cannot be considered successful because of severe mosaic infection and root-knot nematode attack which resulted in low yields obtained.

A study on the time effect of shading tobacco upon yield and quality was made in the 1934–35 season at the Los Baños Economic Garden, Laguna, by Peralta and Paguirigan.(11) Instead of the standard cheesecloth, they used a substitute shading material—a rough abaca cloth with 10 mesh to the inch. The shading was started four weeks after transplanting for the first test, followed by increasing the shading period at weekly intervals for the other test. Observations were made of the weather, both in the shade and outside, of its components, such as temperature, humidity, evaporation, and rainfall. The effects of shade was observed upon the maturity, height, size, number and weight of leaves, and yields of the cultures. Observations were also made on the form and structure of the leaves.

The following conclusions were drawn from this study:

1. High-grade leaf tobacco wrappers can be produced under abaca-cloth shade in the Philippines.
2. Although the cost of production of shade-grown wrappers per hectare amounts to about ₱900, a gain of not less than ₱600 can be realized.
3. The highest profit can be obtained by shading Simmaba variety. Under normal conditions the highest yield can be obtained by shading tobacco 5 weeks after transplanting. .

Methods of culture.—A comparative test (1) of two methods of culture, with the use of Baker Sumatra, was made under identical soil conditions. These methods may be briefly described as follows:

1. The intensive or Sarunayan method consists of three steps, namely, (*a*) Pricking the seedlings 7 centimeters apart each way; (*b*) transplanting them in the field at the age of 45–50 days from the date of sowing with earth adhering to the roots, and a tumbler of water poured after the plant has been set; and (*c*) ridging the rows by cultivators and hand tools, and never cultivating them with the plow.

2. The extensive or native method as practiced in the Cagayan Valley, is as follows: The seed is broadcasted thinly in the seedbeds and the seedlings are pulled from the beds. Cultivation is made with the plow.

The results, which speak for themselves, are given in the table below:

TABLE 2.—*Showing the comparative results of the intensive and extensive methods of culture at Pikit in the 1923–24 season.*

Culture	Yield per hectare in kilos					
	Total	Wrappers	Binders	Fillers	Wrappers	Binders
					Per cent.	*Per cent.*
Intensive method	1,217	292	339	586	24.0	27.9
Extensive method	894	118	209	567	13.2	23.3
Difference in favor of the first	323	174	130	19	10.8	4.6

This test was repeated in the Sarunayan Station in 1925–26 and again in the Ilagan Station in 1928–29.(12) The results show that the intensive method is superior to the extensive. At Ilagan, however, the yields were lower, principally owing to the fact that Cotabato Province, where the first two tests were conducted, was more ideal for wrapper production than Isabela Province.

The results of the test are tabulated as follows:

TABLE 3.—*Showing computed yield of tobacco from the two methods of culture at Sarunayan, Cotabato, in 1925–26.*

Culture	Yield per hectare in kilos			
	Total	Wrappers	Binders	Fillers
Intensive method	1,201	188	412	601
Extensive method	637	82	143	412
Difference in favor of the first	564	106	269	189

TABLE 4.—*Showing computed yield of tobacco from the two methods of culture at Ilagan, Isabela, in 1928–29.*

Culture	Yield per hectare in kilos			
	Total	Wrappers	Binders	Fillers
Intensive method	944	115	163	666
Extensive method	790	78	112	600
Difference in favor of the first	154	37	51	66

TABLE 5.—*Summary of expenses and income incurred in the three places derived from Tables 2, 3, and 4.*

Method	Pikit, Cotabato	Sarunayan Cotabato	Ilagan Isabela	Remark
	Pesos.	Pesos.	Pesos.	
Intensive	507.42	541.11	36.28	Profit
Extensive	20.99	107.56	39.67	Loss

Exact record of expenses for every operation was kept throughout the experiments and prices were given for every grade of tobacco produced. The very illuminating and convincing fact is that the results of the extensive method were obtained at a loss in spite of less expense. On the other hand, the intensive methods, in spite of slightly larger outlay of capital, gave profits. This was due mainly to the greater amount of wrapper leaves produced in all the three tests.

The intensive method of culture insures for the tobacco rapid growth as the plants do not receive a shock at transplanting; fairly uniform development, and an even stand with replanting reduced to the minimum—conditions the immediate results of which will be fine wrapper leaves.

Sumatra method.—When this method was used in second-growth or virgin forest at the Sarunayan Station the tobacco seems to attain maximum development. The leaves are large and rapidity of growth is shown by the plants even when no plowing has been done. With our first trial in the 1925–26 season the stand was the best the writer had ever seen in all his work. With rapid development and even stand, naturally more wrappers are produced and the yield is correspondingly increased. But there are some disadvantages. One, which may render the crop for wrapper at total loss, is the prevalence of fungous diseases, especially if the weather is too wet during the growing and maturity periods. This should be obviated by a good system of drainage canals and adequate banking. Another, which can be prevented, is the prevalence of insect pests, more so in forest than in talahib or cogon lands. More frequent use of insecticides aided by adequate hand picking would markedly reduce the depredations of insects on newly opened land.

REGIONAL ADAPTABILITY TESTS

Paguirigan et al.(13) endeavor to present supposedly comparative cultures of Ilagan Sumatra conducted simultaneously at the Davao Penal Colony, Davao; at Los Baños Economic Garden, Laguna; and at the Central Experiment Station, Manila. With only the comparisons of the physical characters of plant and the leaf products of the three places and that of the genuine Sumatra imported leaf, the work reported in detail deals exclusively with the Davao tests. The results would have been more enlightening if the Los Baños and Manila tests were also presented.

The authors conclude that:

Fine grade of cigar-wrapper was raised at Davao. The size and color of leaves compare favorably with the famous Sumatra cigar-wrapper leaf.

The monthly rainfall observed at the Davao Penal Colony during a period of four consecutive years compare favorably with the mean monthly precipitation of Medan, Sumatra. With this condition and the use of a good variety of tabacco, cigar wrapper tobacco can be raised under open condition at the Davao Penal Colony with a big margin of profit. In so far as the places tried are concerned, Davao is the best place, but still it is possible that some other places in Mindanao may be more appropriate for the growing of open-grown cigar wrapper leaf tobacco than Davao. We are still in search of this place.

Obviously the authors overlooked the results properly reported and published(1) over a decade preceding these tests of the Pikit, later Sarunayan Tobacco Experiment Station in Cotabato Province.

PHYSIOLOGY OF TOBACCO

Salt requirements of tobacco.—Peralta(14) made these studies on salt requirements of Ilagan Sumatra tobacco in the tobacco season of 1934–35 at the Central Experiment Station, Manila. Three types of culture solutions were employed and they differed principally as regards the form of nitrogen used: Type I—nitrate nitrogen; Type II—ammonia form; and Type III—both forms. These culture solutions varied in salt proportion, but all had the same total concentration (gram-molecule per liter of all salts). The author presented tables showing proportion and concentration of salts, data from cultures and those where boron in the form of H_3BO_3 was added to the complete nutrient solutions. The following conclusions were drawn.

1. The most promising nutrient medium for tobacco has about 0.132 gram-molecule per liter (of all salts.) in the following proportion: KH_2PO_4: $Ca(NO_3)_2$: $Ca(H_2PO_4)$: $MgSO_4$ = 2:6:1:2. Trace iron in the form of ferric phosphate or ferrous sulphate was added to the constant medium.
2. In addition to the 10 essential elements needed for normal growth of higher plants, a little amount of boron is absolutedly necessary in order for the plant to develop to full maturity. Absence of boron causes the death of the terminal bud.
3. The addition of a small quantity of $Ca(H_2PO_4)_2$ to a nutrient medium containing KH_2PO_4, $Ca(NO_3)_2$, $MgSO_4$, $FePO_4$, and H_3BO_3 improves the nutritive value of the mixture.
4. The tobacco plant develops vigorously in a complete nutrient medium containing nitrate nitrogen. Using ammonium sulphate without the presence of nitrifying bacteria retarded the growth of the plants.

Water requirements.—In an experiment conducted at the Ilagan Station in 1928(10) using 100, 80, 60, 50, 20, and 5 per cent saturation of the soil, the 60 per cent saturation gave the best result. Due to the unequal difference of percentage of

saturation used in the test which varies from 15 to 30 per cent, this test is not very reliable.

Effect of variation in moisture content of sandy soil upon wrapper-leaf tobacco.—Peralta and Paguirigan (15) made pot studies under a greenhouse on the effect of moisture on growth, total height, dry weight of leaves, breadth index, average number of leaves and leaf product (length of leaf × width of leaf.) Supplementary studies on the resulting product such as color of ash, burning quality, and chemical content were likewise made. Two trials of ten plants each were made and in each case one plant was subjected to increasing saturation by 10 per cent beginning from 10 per cent to 100 per cent. The unit in these tests was therefore the plant and with only two replications. More replications would have increased the reliability of results and the saturation made starting at 5 per cent and multiples thereof or 20 saturations in all.

The authors made the following conclusions:

> Under greenhouse conditions, potted tobacco plants grew best when the range of soil moisture was between 60 and 70 per cent saturation. They did not only produce the heaviest yield but also the leaves raised had the best quality. Plants grown in 10, 20, 30, 40 and 50 per cent saturations had leaves with very poor growth capacity and the leaves also contained high nitrogen and nicotine contents. In the 80, 90, and 100 per cent saturations, the amount of nitrogen and nicotine contents of the leaf were low and the duration of glow was long, but the leaves were yellowish-red, coarse, and non-elastic.
>
> Percentages of soil moisture lower than 60 and higher than 70 per cent saturations were found unfavorable to both growth and yield of tobacco plants. The soil, therefore, for tobacco raising, particularly of the wrapper type must be well-drained and at the same time it must be of such quality as not to part with its moisture too easily in a period of dry weather.

TOBACCO MORPHOLOGY

Gross morphology.—Studies of morphological characteristics of tobacco strains in order to define the original principal varieties—to the end of clarifying the maze of numerous named so-called strains and varieties in this country—are wanting. Reasons why this cannot be easily undertaken were due to the multiplicity of natural crosses occurring in the field and also the equally numerous local nomenclature. Often one variety,(16) like the easily distinguished Romero, is known by a score of local names, such as Catabacuan, Daraoisois, Capigued, Bacari, Tettalay, Cacites, Antolin, Cacites n̄ga Lubag, Morada, Renta Pugot.

Of course, a guide which Priego[17] wrote contains some description of the original varieties up to the year 1894.

Morphological studies, however, were availed of in breeding work notably by Gutierrez[18] in describing the parents and the resulting hybrids carried out at the Pikit Station, Mindanao, and the parents and resulting selected strains at the Ilagan Station, Isabela.[24]

Paguirigan[19] made a rough descriptive differentiation by a simple key of six cigar filler varieties: Romero, Pampano, Espada, Marogui, Repollo, and Vizcaya; three cigar wrapper varieties: Ilagan Sumatra, Baker Sumatra, and Bx–27; four Virginia varieties: Warne, Big Warne, Adcock, and North Carolina Bright Yellow; one white Burley and one Turkish—Samsoun Bafra. In an earlier attempt,[20] the same author included two wrapper varieties, the Florida Sumatra and the Havanensis.

CHEMISTRY OF TOBACCO

Nicotine content.—The quality of Philippine cigar filler tobacco is considered mild owing to its low nicotine content, varying from 1.16 per cent for Simmaba to 1.84 per cent for Romero[21] averaging 1.42 per cent for five varieties including Vizcaya, Repollo, and Espada in addition to the two mentioned. As cigar wrapper leaf is still milder to almost neutral in taste, the analyses showed naturally lower nicotine contents. Baker Sumatra gave 1.46 per cent, Florida Sumatra 0.77 per cent, and Ilagan Sumatra 0.82 per cent, or an average of 1.016 per cent nicotine for the three varieties analyzed.

CURING TESTS

A comparison of five methods of poling leaves for curing was made at the Dammao Tobacco Station, Gamu, Isabela (precursor of the present Ilagan Station) in 1923.[2] These methods were:

1. Leaves face to face and back to back. Sumatra method.
2. Leaves face to back.
3. Cuban method, in which the leaves are strung through the petioles (laterally), making them ride alternately on pole and arranged in such a way that the midribs are exposed on both sides and the lamina turned in.
4. Native method, 100 leaves to a meter of stick (palillo) partially curing leaves in the sun and afterwards hanging them in the curing shed. Control.
5. Native method of partial sun-drying and afterwards hanging them under the house (with no walls).

The first three methods were found to be more satisfactory than the native methods. The Cuban method No. 3 cured faster by one day than the first two, but this difference was insignificant.

TOBACCO BREEDING

Effect of continuous selection.—Paguirigan et al.(22) report the result of continuous selection for six seasons of several varieties, but we are only concerned with the wrapper varieties Baker Sumatra and Florida Sumatra. Number of leaves, their breadth index, height of plants and yield per hectare were taken during the period and were studied. Conclusions drawn applicable to the two-named wrapper varieties were:

The application of continuous selection in tobacco production has generally no advantageous effect on the mean of the breadth index of the leaves, the height of plants, and number of leaves.

The results of the 1934–35 season show, with respect to the wrapper varieties, that Florida Sumatra produced a greater number of standard leaves than Baker Sumatra or 31.1 ± 1.01.

Baker Sumatra gave a higher yield per hectare than Florida Sumatra, which is 15.5 ± 0.50 quintals.

The range of variation in yield per hectare of Baker Sumatra is not significant.

Standard deviation and coefficient of variability are directly proportional to the range of variation in any character.

The difference in the results obtained for the different seasons of any single variety is largely due to the existing climatic conditions.

Utilization of F_1–generation hybrids for crop improvement.—Using F_1–hybrids for increase of yield, Paguirigan and Ramos(23) made the following crosses: Ilagan Sumatra × Vizcaya and Ilagan Sumatra × Simmaba (Marogui). During the 1935–36 season, the F_1 of the first cross yielded 20 per cent more than the low-yielding Ilagan Sumatra, 2 per cent more than the high-yielding Vizcaya and 11 per cent more than the average of two parents.

Hybridization followed by purification and strain selection.—As the Philippines did not have any distinct wrapper varieties or strains, it was not only necessary to introduce the best wrapper varieties from abroad, but also to endeavor to produce native wrapper strains by hybridization or the infusion of the varietal wrapper characters of the imported to the filler varieties having more desirable characters for the purpose, or by crossing different adapted wrapper varieties.

The pioneer work along this line was started at the Pikit station in 1922 by Gutierrez.(18) The best imported seed, the

Baker Sumatra, was used to improve the Florida Sumatra, Dammao Broadleaf (Pampano), Connecticut Broadleaf, and Havana. Later after conducting plant-to-the-row tests, Gutierrez considered the reciprocals of Florida Sumatra and Baker Sumatra the best. Two strains of the Baker Sumatra x Florida Sumatra, Ax–11 and Ax–16, and one of the Florida Sumatra x Baker Sumatra, Bx–27, were considered worthy to be perpetuated. These strains were subsequently tried commercially at the Tabacalera Hacienda of San Antonio, Ilagan, Isabela, and gave very gratifying results, especially Ax–11 and Bx–27. The Ax–11 named "Davao Sumatra" is a misnomer as Davao never had any Sumatra tobacco, except that introduced by the Tobacco Research Section.

The same worker,(24) in the 1928–29 season tried to improve the best filler variety, the Vizcaya, and crossed it with several varieties, as shown in the following table.

TABLE 6.—*Crosses of the Vizcaya variety with other varieties tried during the 1928–29 season.*

Symbol	Cross	Object
Fx	Vizcaya x Ax-11	To obtain light colors and greater elasticity.
Gx	Vizcaya x Bx 27	For greater breadth index, more rapid growth and fine leaves.
Hx	Vizcaya x Baker Sumatra	For mosaic resistance and fine leaves.
Ix	Vizcaya x Sumatra Am.-grown	Fine veins and more fallow colors.
Jx	Ax-11 x Sumatra Am.-grown	Fine veins and greater breadth index.

Since this work was followed for six continuous years, it had undergone a series of selecting and purifying strains and lastly strain tests. Complete data on practically every character including mosaic disease susceptibility were recorded and critically studied. In the strain test the wrapper yield and wrapper grades were included in the final choice of the strains for perpetuation. The following is the summary after the strain tests:

1. All the strains tested are now constant and show remarkable uniformity of type within the strains. The strains differ in botanical morphological characters and behavior and they should now be considered as distinct races or varieties.

2. They differ in their individual susceptibility to pests and diseases. Within the hybrid, the most nearly resistant to the mosaic disease are the Hx hybrid lines, especially Hx F_5–1, followed by the Ix F_5 hybrid strains.

3. From each hybrid, the best results, confirming the findings in previous tests, in wrapper qualities were shown by Gx F_5 — 34; — 14; Hx F_5 —1; —16; Ix F_5— 3 and — 1. These can be distributed to planters for the commercial production of wrapper tobacco.

4. The culture to which these strains were subjected was a compromise between the elaborate wrapper, and filler cultures, and it is to be expected that under the elaborate culture, these strains will give a better account of themselves. The strains showed high adaptability to Ilagan, Isabela, conditions.

5. Depending upon the method of culture, these six best strains of the three hybrids can be expected to produce a preponderance of the wrapper crop or both wrapper and filler crops.

6. The original objects in making these crosses have been attained in some of these strains.

One of the strains of the Gx-hybrid was furnished shade-growers in Tubao Valley, La Union, and the growers named it Simalisay. The Hx–1 strain was nearly resistant to the mosaic disease, and the Tobacco Experiment Station at Medan, Sumatra, was interested with it.

Almost simultaneously with the above work, the Ilagan station performed(6) also some hybridization work along similar objects. The following table shows the hybrids in culture at the Ilagan station in the 1930–31 season.

TABLE 7.—*Hybrids in culture at the Ilagan Station in the season of 1930–31.*

	Parents	Generation	Yield per Ha. in K: Total	Yield per Ha. in K: Wrapper
				Per cent.
4a	Florida Sumatra x Sumatra	F_2	1,680	11.9
4b	do	F_2	1,800	4.4
5a	Maiogui x Sumatra	F_2	1,760	4.5
5b	do	F_2	1,400	5.7
8a	Vizcaya x Sumatra	F_2	2,300	12.2
8b	do	F_2	1,800	13.4
9a	Vizcaya x Florida Sumatra	F_1	850	11.8
9a	do	F_2	2,160	13.4
9b	do	F_1	1,250	12.0
9b	do	F_2	2,410	33.4
10a	Vizcaya x Ilagan Sumatra	F_1	1,640	8.7
10a	do	F_2	1,880	9.9
10b	do	F_2	2,400	3.3
14a	Ilagan Sumatra x Florida Sumatra	F_1	1,000	8.0
14b	do	F_1	1,640	7.5

NOTE: The "a" series represents the original crosses while "b" the reciprocals.

At Ilagan Station(10) the Romero x Sumatra F_1 behaved as intermediate type between the two parents used.

TOBACCO PESTS AND DISEASES

PESTS

The defunct Bureau of Agriculture(25) listed four tobacco pests, namely, the cut-worms (*Prodenia litura*), the false bud-worm (*Chloridea assulta*), the stem-borer (*Gnorimoschema*

heliopa), and the tobacco horn-worm (*Acherontia lachesis*). The life history, habits, destructive stage, and control methods are given and control measures are handpicking or by insecticides, particularly calcium arsenate.

A parasitic hymenopterous insect (*Microplitis manilae*) has been reported to attack the larva of *Chloridea assulta.*

The *Prodenia* is also parasitized by a tachinid fly. A mud dauber wasp has been observed many times carrying small larvae. Birds of many kinds prey on cutworms to a certain extent. The planter should encourage these birds by putting up nests in T-shaped perches and providing shade in the field as done in America and other countries, and by protecting them from idle boys.

A predaceous hemipterous insect (*Euagoras plagiatus*) has been observed sucking the body juices of both larvae of *Prodenia* and *Chloridea.* The protection and propagation of this insect friend may help the planters.

DISEASES

Clara(25) described, gave causes and control measures of the following tobacco diseases: Damping-off diseases (*Pythium debaryanum, Phytophthora nicotianae, Sclerotium rolfsii, Rhizoctonia,* etc.) bacterial wilt of tobacco (*Bacterium solanicearum* E. F. S.), Fusarium wilt (*Fusarium* sp.) root-knot (*Heterodera radicicola*), Sclerotium Blight (*Sclerotium rolfsii* Sacc.), mosaic disease, and cercospora leaf spots or frog-eye (*Cercospora nicotianae*).

The most serious of the above diseases are the damping-off in seedbeds, the bacterial wilt in the Ilocos coast, and the mosaic diseases everywhere. While the *Cercospora* leaf spot disease is also present everywhere, especially during abnormally wet weather, it is not so bad as the tobacco wilt or the mosaic disease.

Green spot disease of tobacco.—Like the tobacco mosaic disease in the United States which produced two schools, differing fundamentally as to the cause of mosaic, one school considering the mosaic of tobacco as pathogenic or caused by filterable virus and another school attributing the cause to physiologic disturbance, chiefly by enzymes: in the Philippines, the green spot of tobacco created two schools of workers, one claiming the cause to be physiologic and the other contending that the cause of green spot was pathogenic. The present writer is

much gratified and feels highly complimented in practically creating great interest for these groups to go to the root-cause of the matter. The physiologic group reports(26): "Gutierrez while conducting wraper tobacco investigations in the defunct Pikit and Sarunayan Stations in Cotabato, Mindanao, had always complained of the frequent appearance of what he termed 'fungus leaf spots' which were colored green."

The pathogenic group was impelled to tackle the work by a statement made at Sarunayan by the writer thus: "During the investigation of the disease in 1927 by the senior author, opinion was ventured by Mr. Mariano E. Gutierrez, at that time Superintendent of the Sarunayan Tobacco Experiment Station, that the green spot is probably due to the initial frog-eye or *Cercospora infections*." It took thirteen long years before workers could prove or disprove the above statements. The green spot on newly cured leaf being a serious blemish made the two groups work seriously with it. In the interim, the writer had proved satisfactorily that the green color of the spots could be eliminated by a thorough and complete fermentation up to 58° C. in two months. The pathogenic group finally established by a well-planned and executed experimental attack of the problem that the causal organism causing the mooted tobacco green spot was *Cercospora nicotianae* E. & E., thus corroborating the statements of the writer.

The principal conclusions of the pathogenic group are as follows:

The absence of pathological studies on the possible cause of the disease is very apparent in any of the previous reports.

Physiological and mechanical injuries:

1. Experiments (according to the method of Paguirigan, Tugade and Peralta) with drops of water on fresh green tobacco leaves exposed to sun rays by means of a hand lens and drops of hot water (70°–100°C) did not produce green spot on cured leaves. The effect of the treatment is analogous to the bluish green color observed by Valleau and Johnson (1936) resulting from the sun scald, which disappears upon drying and curing the leaves.

2. Likewise, with artificial injuries made by a white No. O Asta pins and No. O sand paper, no spots were obtained.

The results of the pathological studies showed that:

1. The green spot or "verderame" is readily reproduced by artificial inoculation with *Cercospora nicotianae* E. & E. isolated from green spot and frog-eye.

2. The green spot or "verderame" is the initial infection of frog-eye or *Cercospora nicotianae* E. & E.

3. The relation between green spot and frog-eye was established.
4. Green spots become frog-eye under favorable conditions.
5. Both green spot and frog-eye are caused by one and the same fungus, *Cercospora nicotianae* E. & E.

COST OF PRODUCTION

Experimental cost.—Using the intensive method of culture, Gutierrez(1) states:

"The expenses on an experimental basis, with due attention to all details incident to production, were ₱750 per hectare. This cost includes management, labor, including animal and housing. The gross average yield of four Sumatra varieties for several seasons varied from 800 kilos in the shade to 1,100 kilos in open fields per hectare. The cost of production per kilo has been from 68 to 94 centavos."

Since the above data were obtained between 1920 to 1926, when the wages of laborers were low, between 30 to 80 centavos per day, the above expenses were good at that time.

At the Ilagan Station in the 1928–29 tobacco season, Hernandez,(12) using identically the same method got ₱610.50 per hectare. Labor wages at Ilagan were about the same rate as in Pikit.

The above cost of production was obtained by a developed method, using mostly animal power for the preparation of the land and all work was done by administration.

In 1931 Gutierrez presented to the Bureau of Plant Industry cost accounts using the Sumatra method of culture with banking as special feature and most of the planting operations done by hand and paid by piece or job basis. His data were based upon actual commercial operations, in which he was engaged for 3 years. The gross cost per hectare amounted to ₱2,516.30 which is more than 3 times the above costs. The net cost after some discounts amounted to ₱1,890.50 per hectare.

It may be of interest to know the different items that made up this large cost by the elaborate Sumatra method, as follows:

	Pesos.
Land preparation including canalization for drainage	135.00
Proportionate cost of shed and laborers' quarters	685.00
Tools and other farm implements	83.30
Seedbed materials	120.00
Worm control	140.00
Fertilizers	100.00
Cost of 25,000 plants at harvest	500.00
For harvesting and bundling	180.00

For curing and curing materials	41.00
Fermentation	20.00
Classification	200.00
Management	120.00
Materials for harvesting and extra help	42,00
Baling	50.00
Freight and delivery service	30.00
Seed harvest	20.00
Incidentals	50.00
Gross total	2,516.30
Less: Inventory value of buildings, equipment, materials, etc.	625.80
	1,890.50

Paguirigan and Tugade(16) made estimates of expenses in 1938 for shade-grown native tobacco with ordinary method of culture. The net cost per hectare amounted to ₱704.00.

FACTORY UTILIZATION

The real test of the worth of the product of research in cigar wrapper leaf should be the marketability of this wrapper leaf and concurrently its actual utilization by well-known factories to wrap their standard brands of cigars. The cigar factories struggling to obtain the Cotabato cigar wrapper in the annual public auction at the Bureau of Internal Revenue were the Alhambra Cigar and Cigarette Factory and the Tabacalera.

Samples of the 1923–24 crop furnished the Alhambra were made to wrap Coronas, and its Manager, Mr. Paul Meyer, furnished the then Governor General Leonard Wood with a sample of the product. The Governor praised the local appearance of a substitute of the expensive imported Sumatra leaf. The success of the factory result was recognized by Governor Wood in a letter to the man in charge of the Pikit Tobacco Experiment Station.

About 800 kilos of this crop(1) were brought for fermentation to the Tabacalera's bodegas in Manila and a study was made by the factory experts on the suitability of this tobacco for cigar wrapping purposes. This tobacco could wrap 416 cigars per kilo of leaf and they expressed the opinion that by a better worm control this number could be markedly increased. At that time the use of calcium or lead arsenate was not yet adopted by the station and worms were killed by hand-picking, which, while more direct, was not so efficient. This tobacco was used for wrapping special Tabacalera brands such as

"Favoritos Dotres," "Especiales Tabacaleras" and "Regalia A. Lopez." The whole stock was bought by the company.

On the other hand, the poor 1925–26 Sarunayan station crop, blemished by *Cercospora* and green spots, was submitted for critical study to a factory as to its merits, if any. The report on this poor harvest was as follows:

1. Better than the Georgia and equal to the Sumatra in taste. The Georgia is always somewhat bitter and it makes the smoker's mouth feel dry.
2. Its burning quality and aroma are very satisfactory.
3. In elasticity, it is the same as the first class Georgia and superior to the lower classes of Georgia.

CONCLUDING REMARKS

The results of the experiments reviewed in the foregoing can now serve as reliable guides for commercial wrapper tobacco plantations. Due to the effect of the last war in temporarily disorganizing the Dutch monopoly of the Sumatra wrapper industry in the Dutch East Indies, especially on the Island of Sumatra, the planting of this wrapper tobacco should be encouraged. When properly developed here, it can be a ₱20,000,000 industry.

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OCCURRENCE OF THE STALK ROT OF CORN IN THE PHILIPPINES[1]

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ONE PLATE

The first notable outbreak of a stalk rot of corn was recorded by the writer during damp, rainy weather in July, 1943 on the experimental grounds of the Agricultural Research Institute, Manila, Philippines, then created temporarily by the Japanese occupation forces. A few of the corn varieties then in culture were found infected in varying degrees, including two foreign hybrids and a promising high-yielding white variety, called Dueñas, which originated from Iloilo Province. The disease could cause as much as thirty per cent damage on very susceptible varieties. The affected plants toppled because of the rotting of the internode immediately above the ground level, while the leaves remained green and turgid for a few days after (Plate 1, fig. 1). For the second time after the liberation, this stalk rot disease has been identified by the writer from specimens collected by Mr. Juan O. Unite, assistant plant breeder,

[1] A report on the studies of this corn disease, entitled "A Foot Rot Disease of Corn," was prepared by G. M. Reyes in 1944 for publication, treating rather comprehensively among other things on the results of inoculation of over thirty varieties and strains, and was accompanied by photographs of the disease taken in the field and at the studio of the former Bureau of Science from the writer's materials. The manuscript together with other valuable data was lost during the battle of liberation.

at the Los Baños Economic Garden, and more recently in July, 1948, the same disease was observed in one of the corn fields at the Central Experiment Station of the Bureau of Plant Industry, Manila, immediately after the first squally and hot, moist days of July, 1948. There seems to be no record of the disease having been reported elsewhere in the Philippines heretofore.

THE DISEASE

The stalk rot disease of corn develops with considerable rapidity during intermittent periods of hot, moist-saturated atmosphere following heavy downpours, and from the time the plants are approximately two weeks old to tasselling period. Immediately above the ground level, raised sometimes unusually high in parts by furrowing, a soil fungus infects one or two internodes at or above the brace roots and sometimes around the node, involving the enveloping sheath, which causes the plant to fall over or lodge because of the pressure of the top as if blown down by a strong wind, oftentimes leaning on other plants or lie prostrate on the ground.

A close examination of infected stalks will show that the tissues, including the rind, are softened and destroyed, very much discolored (Plate 1, fig. 2), brown to grayish black, shrunken and water-soaked, emitting a peculiar, somewhat "marshy" odor at the advanced stage of decomposition. The nodal tissues are generally much less affected. Any portion of an actively developing infection (Plate 1, fig. 2), if kept in moist chamber overnight, will readily produce a mass of cottony white, fungous growth. When a fallen plant is pulled out, it readily snaps off at the affected portion of the decaying or decayed stalk.

The disease appears all of a sudden from infested soil when favorable weather conditions obtain even on vigorous growing plants, and no stunting takes place. The aerial parts of the fallen-down plant above the seat of infection remain normally green (Plate 1, fig. 1) until after a week or so, supported meanwhile by the more or less disturbed functioning of the dark-brown fibrovascular bundles. The tips of a few fallen plants have been found to react in the direction of the sunlight. The roots grow in abundance and are normal as well as the portion of the stalk below the infected part (Plate 1, fig. 3).

THE CAUSAL FUNGUS

All isolations made of the infective agent from young infections invariably yielded a fine, white, filamentous fungous growth which is closely similar or identical with the Pythiaceæ group, the morphological characters of which will be examined and illustrated microscopically in detail. On account of the economic importance of the disease, the study of the taxonomic position of the causal fungus was put aside for a later date. Suffice it to say that it is a parasitic soil organism belonging to genus *Phytium* which has a wide range of distribution and host suscepts in some tropical countries and subtropical regions having warm climates.

The pathogenicity of this causal fungus with the use of pure cultures has been sufficiently established previously, producing typical characteristic rotting of the stalks in the laboratory, greenhouse, and in the open field that there leaves no room for doubt that it is a pathogen of potential significance. The same symptoms have been repeatedly produced, and the same fungus has been indubitably recovered and found to answer favorably the essential features of the isolate used.

What remains to be accomplished is how to maintain the isolates as virulent as possible under present circumstances with a view to determining the susceptibility or resistance of our commercial and promising varieties now extant and those recently introduced. In other words, this would mean a repetition of the same arduous task in subjecting the over thirty varieties and strains generally grown in various parts of the Philippines and perhaps more, which are now being assembled gradually for the purpose.

VARIETAL SUSCEPTIBILITY

The difference in the susceptibility of local and foreign varieties and strains, [2] determined by artificial infection with a pure culture under favorable environmental conditions, is summarized somewhat in the order named, as follows:

Susceptible varieties.—Wisconsin Hybrid, Pangasinan Yellow Flint, Nueva Ecija Yellow Flint, Cuban Yellow Flint, Los Baños Lagkit, Maligaya Glutinous Corn and Batangas Yellow Flint.

Moderately affected varieties.—Pampanga Yellow Flint, Dueñas White Corn, and a strain of Batangas Dumali.

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[2] Thanks are due Mr. Juan O. Unite, assistant plant breeder, for affording all available plant materials for inoculation purposes.

Resistant varieties.—College Yellow Flint and Indang Yellow Flint.

In the absence of a better immediate information due to the unavoidable loss of the figures accumulated thus far, these reactions may be considered tentative, until the duplication and production of further or perhaps more substantial results.

CONTROL

From trials and observations made in previous work, off-barring was found beneficial in lessening the damage, but some care must be taken to avoid injury to the roots, especially the brace roots.

Removal of the sources of infection, if possible with some of the infested soil around, is advisable to avoid any possibility of spread and its subsequent disastrous effect.

Plowing the land after harvest in order to give it plenty of aeration and to expose the fungus to prolonged sunlight would greatly help reduce the recurrence of the disease.

Rotation with legumes is also recommended to starve out the fungus in the soil; or a change in the season of planting would prove more beneficial. Any modification in time of planting should be a deviation from bad weather which coincides, it seems, with the critical growth period. This corn disease is so contingent with moisture and thermal conditions that unless the soil is infested, the disease is not likely to appear, however.

The most economical method of controlling this disease is the substitution of resistant varieties or strains in areas much affected by the stalk-rot disease.

ILLUSTRATIONS

[Photographs by the Division of Publications, Department of Agriculture and Natural Resources]

PLATE 1

FIG. 1. Full view of three Java corn plants showing varying degrees of infection at the critical period of growth by the stalk-rot disease (pointed by arrow). Note the healthy condition of the tops.

2. Closer view of basal portions of two corn plants fresh from the field showing early and quite advanced infection of the stalks.

3. A longitudinal section of an infected stem showing infection in two internodes of the susceptible region. Note the healthy tissues of the upper and lower portions of the stalk and also of the roots.

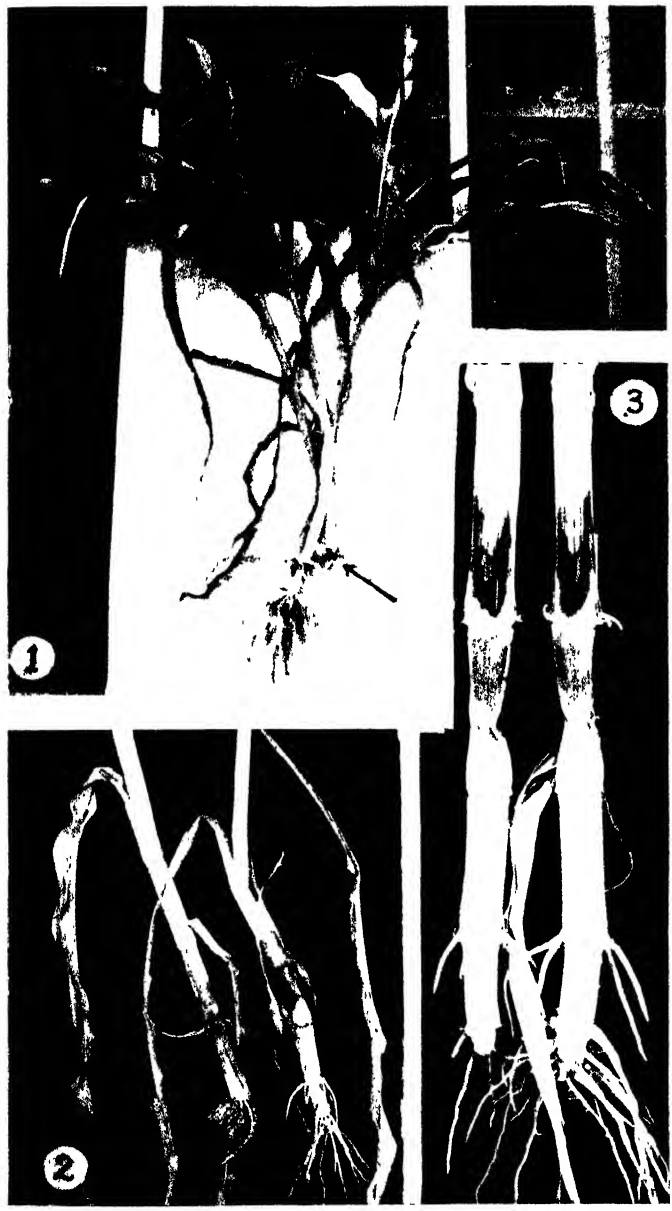

PLATE 1

BEGONIA CULTURE IN THE PHILIPPINES[1]

By LORENZO SEGGAY
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EIGHTEEN PLATES

The begonias, *Begonia* spp., are a group of plants, many of which are cultivated and highly valued as ornamental potted plants. They are grown primarily for the beauty of their foliage and secondarily for their flowers. The leaves of most of the types and varieties have various color combinations which make them very attractive and highly decorative.

Merrill(4) mentioned wild forms of begonias to have existed in the Philippines from time immemorial. In fact, reference to Philippine begonias is found in pre-Linnean botanical literature. However, scientific interest in Philippine begonias began only after the publication of Blanco's Flora de Filipinas in 1837 where a single species was described. Since then a few wild forms have been described, but it was only at the beginning of botanical exploration under the American regime that greater interest was noticeable in the classification of Philippine begonias. In this connection, it may be mentioned that no attempt in the study of the cultivated forms has been made by the previous writers although these forms, as Merrill(4) claims, were already then in cultivation in Manila.

It is probable that the culture of the highly decorative varieties which are mostly exotic is linked with the modern development of floriculture in the Islands which was in all likelihood started in 1898 by Regino Fermin, a famous floriculturist in Manila. It is believed that since then, the value of the begonias as ornamental plants has gradually gained greater importance. Some fifteen to twenty years ago, these ornamental plants were a craze and their spread throughout the Islands was inevitable. However, the spread especially of the rare varieties was almost exclusively confined to the rich who could afford the rather prohibitive prices.

[1] Revised by Mr. P. A. Rodrigo, chief, Horticulture Research Section, Bureau of Plant Industry. Submitted for publication October, 1941.

Many begonias are very exacting in their cultural requirements. The perennial problem of the begonia growers is to find means of facilitating the propagation and improving the care of these extremely delicate plants. Their propagation and care are time-consuming and it is only through a sufficiently long experience in the handling of these plants that one can learn the secrets of their behavior which could be taken advantage of in their culture. This is especially true because of the absence of Philippine literature along this line. The decline in the popularity of the begonias some eight or ten years ago, when their culture was almost exclusively confined to a few commercial nurseries, begonia fanciers and plant conservatories, may be directly attributed to the failure of amateur growers. The begonias when not properly taken care of do not give the beauty and the luxuriant growth that make them very attractive. It is the aim of this paper, therefore, to bring together some important pointers in the handling of these plants based on a twenty-year experience of the writer and to contribute something to make these beautiful plants of greater use in the decoration and beautification of Filipino homes.

TYPES OF BEGONIAS

There are minor, yet important, differences in the culture and care of the different kinds of begonia. It is, therefore, important that the begonias are arbitrarily classified to facilitate the discussion of their cultural requirements. This classification, therefore, is not systematic. The following types are widely known in the Philippines:

1. Climbing type.
2. Creeping or hanging type.
3. Tree or flowering type.
4. Rex, decorative or fancy type.

Of the foregoing types only the last three are being cultivated. The decorative, or fancy, type is the most popular. The tuberous type, which is much more admired than the fancy type in other countries, is still unknown in this country. Attempts made by the Bureau of Plant Industry in the acclimatization of this type have not so far met with success.

Climbing type.—The species or varieties[2] under this type are mostly found growing wild in Philippine forests, at altitudes

[2] Variety is loosely used in this paper. It refers to any of the different kinds although the variation is very slight.

of from 400 to 1,000 feet above sea level. Merrill(4) reports that wild species of Philippine begonias are found in the forests in nearly all provinces. They climb on anything especially on big trees and tree ferns. Some begonias are about 3 to 10 meters long.

The small-leafed climbing varieties are very picturesque. They climb on trunks of trees with many branches hanging down. If the support is completely covered, as in the case of a shrub, the form will be like an umbrella. The plant with its silvery, light green, serrated small leaves and with its small brilliant flowers, which are white or pink and borne in small clusters on almost all the axils of the leaves, appears very attractive. The stem is small, about 5 mm. in diameter, yellowish to whitish pink when young but dark brown and seems to be woody like the bettle pepper when mature. Any collection of begonias, however extensive, does not seem to be complete without this type.

The broad-leafed climbing kinds appear like the variegated Aroids or Pathos (Plate 1). The leaves are borne on both sides of the stem; they are broad, measuring from 25 to 30 cm. long and about 15 to 20 cm. wide; thick and very shiny; pale green and smooth with few hairs on its outer surface. The petiole which is about 23 to 35 cm. long is hairy. The stem is fleshy and tender, flat and hairy, measuring about 2 to 3 cm. thick, and internodes about 10 to 15 cm. long. The flowers are in bunches, deep orange when still in the bud stage and orange pink when open. A single flower measures 3 to 4 cm. across. The flower stalk measures about 50 to 65 cm. long.

Creeping or hanging type.—The species or varieties under this type are found growing wild at low altitudes in Philippine forests. They grow on decaying logs, moist cliffs, banks and even stones. To some extent, plants of this type are cultivated in the lowlands as potted window garden plants (Plate 2, figs. 1 and 2).

Begonias of the creeping type in general, resemble the climbing type, only that they vary in nature. They do not climb even when provided with support, hence the name. If they cannot creep anything, they simply hang down (Plate 2, fig. 2). Their stem is succulent and tender, sometimes reaching a length of from 50 to 100 centimeters. Generally the stem is reddish, although greenish gray may be found. The leaves vary in size depending upon the variety, from small to large, the big ones measuring about 9 cm. long and 9.5 cm.

wide. Various color combinations are exhibited by plants belonging to this type. The flowers are small and about 20 of them form an inflorescence.

Tree or flowering type.—The varieties or species under this type are bunchy and erect, suggesting the appearance of a small tree or shrub. Although they are more like a small shrub, their branches could be trained to form any shape as in the case of *Bigonia magnifica* Bull., a woody vine. Both tall and dwarf varieties are found under this type, the tall one attaining a height of from 2.5 to 4.5 meters, and the dwarfs ranging in height from 30 to 60 cm. The dwarfs are generally tender while the tall ones are hardy.

The tree or flowering type of begonia is grown more for its flowers than for its leaves. The flowers which are very much larger than those of the creeping type are in clusters and are pendant. The color varies from white to pink of different shades to deep red.

There are only a few varieties or species of this type that are under cultivation, and most of these are exotic. The most popular of the tall kinds are Australian and Brazilian varieties (Plates 3 and 7). Of the dwarfs, the most admired varieties are Conchita, Tree de Plata, Tree Peluz, Begonia de Man and Begonia de Malbarosa (Plate 4, figs. 2 and 3).

Rex, decorative or fancy type.—The varieties or species under this type are the most important and fascinating of all begonias in the Islands. They are grown for the beauty of their leaves which exhibit a magnificent array of color combination and blending. The leaves are, in general, broad, from 10 by 8 cm. to 35 by 38 cm. with few trichomes on the nether surface. The petiole is erect and hairy, measuring from a few centimeters to about 30 cm. in height.

The basic color of the leaf is metallic, blended with various sorts of combination and arrangement of color so that in justice to their beauty they have to be actually seen to be fully appreciated. The leaves of this type also have fanciful shapes as vividly illustrated in Plate 8. This type of begonia has very short fleshy stem, thus making it very suitable for pot culture (Plates 5, 6, 9, 10, 11, 12 and 13).

While the leaves are the main attraction of the decorative type, the flowers are also beautiful. Most of the flowers are pink or orange of various shades; some are odorless, others with sweet fragrance but still others with some unpleasant odor like that of the flower of bañgar (calumpang, Tag.), *Sterculia foetida* L.

The decorative type is rich in varieties and strains. It is believed that there are no less than 150 kinds in the Islands. Among the most popularly grown in Manila and in neighboring provinces, the following varieties may be mentioned:

American Beauty	Giant
Antiguo de Caracol	King of Begonias
Bandera Africana	Lady Helen
Bandera Cubana	Merry Widow
Bandera Frances	Maria Clara
Cenefa de Caracol	Peluz
Diamond	Plata Caracol
De Seda	Pink Caracol
De Oro	Principe de Asturias
Green Caracol	Principe de Araña
Principe de Espada	Royal
Principe de Angel	Royal No. 1
Queen of Begonias	

REQUIREMENTS OF BEGONIAS

1. *Climatic requirements.*—The begonias are very particular in their climatic requirements, these being one of the most important limiting factors for their successful growth. They grow best in regions that are comparatively cool, moist with moderately well-distributed rainfall throughout the year. Torrential and heavy rain, strong wind, particularly the dry and strong sunlight are inimical to the proper growth and development of begonias. Begonias can be grown in practically any place in the Philippines if a suitable greenhouse is provided. However, there are some kinds of begonias that can be grown fairly well in dry regions. The tall varieties of the tree type are good examples. The decorative, tuberous and climbing types are more suited to comparatively moist and cool climate. The climbing type is the one most suitable to higher altitudes.

a. Water or moisture requirements.—The successful culture of the begonia is closely linked with the water or moisture supply of the plant. Too little or too much water is detrimental to the well-being of the plant. Between the two evils, excess of water is far worse; the plant is never healthy under watery soil. Oftentimes, excess water causes rotting and falling off of the leaves and slow decay of the roots. On the other hand, the begonia should not be allowed to suffer from lack of water as to cause wilting because the loss of much turgidity of the leaves is one of the causes of blistering and drying of the edges of the foliage. Defects like these mar the beauty of the plant.

The best moisture content of the soil in order to have good growth and healthy appearance of the plant is when the soil does not readily stick to the finger upon handling. From long experience, it has been found necessary that during the rainy season, begonias should be watered once or twice a week if they are kept in greenhouses. During sunny days, three waterings a week or once in every three days has been observed to be sufficient. However, during the summer months, watering the plants once a day, preferably in the afternoon is necessary. There is no harm in watering the leaves if done either in the morning or in the afternoon. In fact, this should be done once in a while so as to wash off the dust that accumulates on the leaves which naturally mars their brilliance and beauty. Wetting the leaves at noon during sunny days should be avoided as water films during hot days cause the edges of the foliage to dry up.

b. Sunlight requirements.—The begonias are shade-loving plants, and grow luxuriantly well in partly shaded places. Thirty to 50 per cent shade with free circulation of fresh air is about the best sunlight condition for begonia. From experience, it is indeed difficult to grow begonia especially the decorative type, without protection from rain and from the strong heat of the sun. The creeping type and the very common varieties of the decorative type can endure continuous hard rain, but in no case can begonias stand the strong heat of the sun for a couple of days.

A greenhouse is the best answer to this requirement of the plant. The greenhouse, however, should be so constructed that there is a free circulation of fresh air and the plants can receive about 50 to 70 per cent of the morning (6:00 to 10:00 o'clock) and afternoon (3:00 to 6:00 o'clock) sunshine. Too much shade is also inimical to the proper development of the plant. The tree type does not flower in a much shaded place while the decorative type does not only lack vigor but also loses the highly prized luster and attractive color of its leaves when it does not receive the proper amount of sunlight.

2. *Soil requirements.*—There is a very slight difference in the soil requirements of the different types of begonia. The tree and creeping types are comparatively hardy, but in order to grow beautiful plants, rich soil is necessary. The decorative and tuberous types are the most selective in their soil requirements. When the soil is poor, the growth is retarted and the plant is incapable of expressing in full the beauty of its leaves.

The fertility of the soil is one of the factors that greatly affect the size and color of the leaves and the ultimate vigor and beauty of the plant.

As a rule, the begonias require a very rich, warm and slightly acidic soil of good drainage. The soil, however, should be kept moist all the time. It should not contain foreign materials, such as undecomposed leaves, stems, and the like, and above all, it should be free from fungous diseases and earthworms.

It is hard to look for an ideal soil for growing begonias in pot. For practical purposes, it is more economical to make some soil combinations of which the following mixtures have been found very good for begonias:

a. Three-fifths ordinary garden soil for every two-fifths leaf mold or peat soil.

b. Three-fifths surface forest soil for every one-fifth leaf mold and one-fifth peat soil.

The leaf mold and peat soil may be substituted with well-rotted stable manures. Soils under ipil-ipil trees (*Leucaena glauca*) or bamboo trees are good substitutes for forest soils.

Manure and fertilizer requirements.—Unlike other plants, the begonias are very sensitive to the application of fertilizers. As far as the writer is aware, no work along this line has been published in the Philippines. The begonias are especially sensitive to the application of commercial fertilizers particularly those containing phosphorus and potassium. Even when applied in very dilute form, especially by amateur growers, commercial fertilizers do more harm than good. Experience bears out the fact that begonia plants treated with commercial fertilizers, even in a very dilute form, usually do not live long.

The application of well-decayed stable manure to sandy soil is beneficial. However, there is the danger of introducing some pests and diseases to the soil, such as nematode rootgall, earthworm, root rot, and others, with stable manures. Humus and leaf mold in nature are the safest and best material to be mixed with soil for begonia culture. When the soil medium has been properly compounded, as already stated, the question of begonia fertilizer is practically of little importance.

PROPAGATION OF BEGONIA

The begonias are commercially propagated by asexual means; however, this method of propagation is only resorted to when it is desired to produce new strains or types of begonia. The

asexual method of propagation can be done in four ways, namely, (*a*) leaf cutting, (*b*) stem cutting, (*c*) side shoots or division, and (*d*) grafting.

Leaf cutting.—This is the easiest and most popular, and the most rapid method of propagating the begonia. The begonia plant is one of the rare species of the plant kingdom and possesses a highly remarkable ability to reproduce itself from leaves. The propagation of begonias by leaves is indeed very interesting. Tissues capable of producing shoots do not only develop on the large veins of the lamina but also on the petioles if the leaves are properly planted and cared for. Naked petioles, however, are as a rule incapable of shooting.

In general, all types of begonia can be readily propagated by leaf cutting. However, there are cases where the plant can be better propagated by stem cuttings, division or by seed.

The small-leafed climbing type, most of the tree type, and the creeping type can best be propagated by stem cuttings or by seed. All varieties of the decorative type can be most advantageously propagated by leaves. Principe de Palma of the tree type and most of the creeping varieties can also be propagated with advantage by leaf cuttings.

The leaf cutting, planted in any position under a good soil, medium and favorable conditions will give practically the same results. The most common practice, however, is to set the leaf standing, its petiole (3 to 4 cm long) with a part of the lamina touching the soil medium (Plate 18). Of course, there are many practices in the propagation of begonia from leaf cutting, ranging from planting the whole leaf as already stated and to the extent of dividing each leaf into two or more sections and using each as a unit. Old, medium, as well as young leaves may be used, although the medium-aged leaf is always the best. It takes longer time for the young leaf to shoot. Also, it is more subject to the attack of damping off, besides requiring more care and technique to handle it. Old leaf on the other hand, is not so delicate as the young leaf, but in general, the leaf blade becomes degenerated before the young plant is properly developed, thus resulting to more or less stunted and weak plants.

The medium-aged leaf has all the advantages; it shoots easily requiring from twelve to twenty days for variety Plata and from thirty-four to forty days for Pink Caracol. The seedling resulting from medium-aged leaf cutting is more vigorous and

better developed than the seedlings from old or young leaves. Furthermore, under normal conditions it can be used for raising a second crop of plants.

From experience, it has been found that it is more advantageous to propagate the begonia during the cool months than at other times of the year, that is, from the middle of September to the end of February, at least under conditions obtaining in Los Baños, Laguna. In drier regions, the time most suitable for propagation may be from September to early January. During these months, rainfall is moderate and the weather is neither too damp nor too hot for the shooting of cuttings and the development of plants. During the rainy season, the developing plants are generally attacked by dumping-off. On the other hand, during the hot months, the leaves of young plants generally get dried or scalded owing to dryness and the heated films of water along the margin of the leaves due to the heat of the sun, hence the difficulty of raising begonia seedlings during the wet and hot months of the year.

Leaf cuttings can best be germinated in pure and well-washed river sand, or in peat soil free from organism causing fungous diseases or in any of the media described elsewhere in this paper. It is better, however, to place the propagating media in a partial shade. The cuttings may also be planted advantageously at the base of growing plants because of the regulated moisture and temperature under such conditions (Plate 14).

How to prepare the leaf for propagation.—There are several ways of preparing begonia leaf cuttings for propagation, namely, (*a*) dividing the leaf into sections, (*b*) using whole leaf with 3 to 4 cm. of its petiole, and (*c*) using whole leaf with its entire petiole.

Cutting the leaf into sections is one of the oldest and most economical ways of propagating the begonia. The number of cuttings made from a leaf depends upon its size and the presence of large veins. Generally, however, two to four cuttings are made from a leaf and each section should at least possess a large vein (Plate 15, fig. 1). These cuttings can be inserted into the soil media in any position, but they should be adequately spaced to allow a free circulation of air so as to minimize damping-off. This method of propagation is not widely used in the Islands owing to the facts that (*a*) germination is rather slow and the resulting seedlings are generally thin and small, and (b) the seedlings are susceptible to the

attack of damping-off. It can be practised with good results with big-leaved varieties of the Rex or decorative type, such as Giant, Repollo, Pink Caracol, and others.

Using the whole leaf with 3 to 4 cm. of its petiole is the most popular method used by begonia growers in the Islands. This method is the best and quickest for obtaining young healthy plants with the use of leaf cuttings. If the cuttings are properly set in the germinating media (Plate 15, fig. 2) and are free from the attack of diseases, two or more crops of seedlings can be harvested or obtained. To induce the production of more seedlings, break the large veins and press them slightly into the soil medium, taking care not to separate them. This kind of leaf cutting shoots in from twelve to forty days depending upon the variety, the soil medium and the conditions prevailing.

The whole leaf with its entire petiole is also commonly used in propagating the begonia (Plate 16 fig. 1, *a*, *b*, *c*, and *d*). The leaf is inserted in the propagating medium so that the petiole is parallel to, and partly buried in, the medium with the leaf blade barely touching the surface of the soil. The leaf blade should not in any way be covered with soil, if it is desired to produce more shoots from a single leaf. The idea is to let the base of the petiole shoot up, and once this is accomplished the young plant that is growing may be separated by cutting the petiole when it has many roots. The petiole is again slightly pressed in the soil to enable it to shoot. The process is repeated many times until the leaf blade has been used. By splitting the petiole, the number of obtainable shoots can be increased; the splitting causes more buds to germinate on the petiole (Plate 16, fig. 2, *a* and *b*).

Stem cutting.—The stem cutting is commonly used in the propagation of the tree, climbing, creeping or hanging types of begonia. While stem cutting of any stage could be used, the top portion of a stem or of a branch of medium age is the best. Inasmuch as the roots arise from the nodes, and from the sides of the stem and not from the cut end as is the case in most plants of the dicots, the cut should be made close to the node and as clean as possible. Stem cuttings of begonia root in from nine to twenty days depending upon the variety, the season and the germinating medium, and they are ready for sale in a little over a month thereafter.

The stem cuttings as a rule are hardy. They can be planted in some germinating media or they may be planted direct in permanent pots. They should be planted in standing position.

When planted first in some germinating media, they should be transplanted in permanent pots as soon as they have enough roots.

Propagation by side shoots or division.—Potted begonias are more or less pot-bound because of the production of side shoots. These side shoots cause crowding in the pot and the plants become stunted and look ugly and unthrifty. The leaves become smaller and smaller especially in the case of the decorative type. To improve the condition of the plants, some of the side shoots should be separated but instead of throwing them away, they can be used for propagation purposes. Using the side shoots is one of the easiest ways to propagate begonia since the side shoots, as a rule, have roots. The drawback of this method of propagation is the limited amount of planting materials. Furthermore, the mother plants from which the side shoots may be removed are rendered more predisposed to the attack of earthworms and nematodes.

Grafting begonia.—The tree type of begonia can be propagated by grafting. Some trials on this method of propagation showed that a complete union between the scion and the stock can be effected in fifteen to twenty-five days. From experience, however, the stock should at least be about a centimeter in diameter and the scion about the same size with a few leaves and a terminal bud. The stock and the scion under favorable conditions will completely unite regardless of their age, although medium-aged scion and stock are preferable. Once the graft has been made, the scion should not be allowed to get dry; it should be kept moist and fresh with sphagnum moss or with similar materials.

Seeds.—All kinds and types of begonias can be propagated by seeds. The growing of begonia from seeds, however, is very laborious, so that this method of propagation is only resorted to when new varieties and strains are desired.

The begonia seed is very tiny. When properly cured, it germinates in from five to twelve days but if sown soon after gathering, it takes from twenty-five to thirty-five days to germinate. The seeds should be sown in a medium similar to that for growing leaf cuttings or on moist adobe rock or sphagnum moss. The soil should be pulverized finely, levelled and compacted a little before the seeds are sown. The seeds should be sown evenly and thinly on the surface of the germinating medium similar to the way tobacco seeds are sown; they should never be covered with soil particles. The germinating medium

should then be placed in a moist, warm but shaded place. If the weather is warm, the seedflat should be covered with a piece of moist cloth or glass to prevent excessive drying of the soil.

The begonia seedlings are slow-growing and delicate to handle. As they germinate the seedflat should receive some morning sunlight, otherwise the seedlings will be weak and spindlelike. It is preferable to place the seedflat in the north exposure where the seedlings will receive diffused sunlight in the morning. Begonia seedlings are injured by dripping water of any kind. Under normal conditions, it takes from five to eight months before a reasonably good-sized seedlings can be had. It is always better to sow the seeds thinly so that the seedlings will not be overcrowded in the seedflat. Properly spaced seedlings are more stocky, and they are more healthy and grow faster.

When the seedlings have three to four leaves, they should be pricked. A medium good for pricking begonia seedlings should contain 50 per cent leaf mold and 50 per cent good garden soil. On the surface, a thin layer of well-washed river sand should be spread. When the seedlings are about 5 to 10 cm. tall, they are ready for planting in permanent pots.

POTTING, REARING AND CARE

Potting.—One of the secrets in the success of raising potted begonias lies in the preparation of the pot for planting. Drainage is an essential requirement, hence the necessity of putting a good layer of small stones or pieces of broken pots at the bottom of the pot. The pot is then filled with good soil as already indicated and the young plant is set in such a way that it is neither too deep nor too shallow. It should be set as deep as it was in the propagating bed. Under no circumstances should the base of the lowest leaf be covered with soil as this may cause the rotting of the leaf and consequently affects the growth of the young plant. The soil around the roots of the plant should be pressed carefully, adding soil if necessary, but allowing sufficient space for watering.

Newly potted begonias should be watered and put in a place where they can receive sufficient diffused light throughout the day. They should not be exposed to strong wind. During the course of recovery, the plants should be watered frequently but sparingly just to keep the soil moist, and the watering should preferably be done early in the morning or late in the

afternoon. As soon as the plants are sufficiently recovered which usually takes from five to fifteen days after potting, they may then be transferred to the begonia house or to a place where they could receive about 30 to 50 per cent sunshine. They should never be placed under some hanging plants because they do not like water falling in drops on their leaves.

The begonias, after all, are easy to handle, but they require constant attention and care once they have started to grow. Success in growing begonias depends a great deal on knowing and giving what they need in the right amount and at the right time. To do this successfully, it is necessary to associate with the plants.

Experience has shown that the begonias, especially the decorative type, react unfavorably to too much handling. They do not want to be moved from one place to another, neither to be turned around. If it is urgently necessary to transfer them from one corner of the greenhouse to another, this should be done gradually. For too sudden transfer affects their growth. The young leaves of the decorative type during the time of transfer wrinkle and will not continue to develop normally. If the delicate varieties are used for decorating the inside of a building during special occasions, they should be so placed in order to have practically the same light exposure as in the permanent place, and at night they should be put outside to receive cool, fresh air. If they show sign of poor growth, it would be better to return them at once to the greenhouse in their respective places, taking care that they asume their former positions.

The begonias are considered perennial plants; that is, they are capable of growing for a number of years. However, in order to have thrifty, vigorous and beautiful looking plants and so as to reduce the many troubles in handling them, they should be rejuvenated from time to time. A good practice is to repot the plant at least once or twice a year or as soon as it shows signs of poor growth. In repotting, any side shoot should be removed with a clean cut; such a shoot if already rooted, can be used for propagating purposes. The idea of removing the side shoots is to keep the mother plant healthy and vigorous by not being crowded. The symmetry of the plant is also maintained.

To make the begonia plant always appear beautiful, all drying and useless leaves should be removed promptly. A goodly number of leaves should be maintained, and to do this, it is

necessary to protect the growing point or terminal bud from injury as this will cause degeneration resulting to legginess and lack of symmetry. If this happens, every effort should be exerted to induce the plant to produce side shoots. Adding new rich soil very often may bring about the desired end.

Another way of making the plant maintain its beauty is to prevent the development of fruits. The development or formation of fruiting pods has a direct relation with the size, glossiness and attractive appearance of the leaves. The production of fruits and seeds takes very much of the energy of the plant, and when this happens, small-sized leaves of dull appearance will be produced instead of the beautiful, shiny, silky or silvery big ones. If, in the course of watering, part of the soil is removed, it should at once be changed with new rich soil. At the same time, the plants should be watched for any insects that feed on them especially the young leaves. The partly eaten leaves are sore spots in a realm of verdant beauty. Any apparent abnormality in the growth of the plant is a sure sign that something has to be done. It is here where the keen eye of the gardener can avert a lot of troubles later on.

SHADES FOR BEGONIAS

The ideal place to grow and rear begonias, particularly the Rex or decorative type, is in the greenhouse. But unless one goes into their extensive propagation and culture, the greenhouse is out of consideration. However, a greenhouse may be constructed to house a host of ornamental plants such as the different orchids, ferns, anthurium, colocasias and many other greens, and in this case a suitable place for begonias may be provided. Granting that the greenhouse is ideally located and constructed, the begonias (Rex) should be placed where they do not receive any water drippings from any source and where they receive sunlight in the morning or in the afternoon. It should be remembered, as has been emphasized in the early part of this paper, that proper light exposure is one of the most important factors in the growing of begonias.

Where the begonias are few and only intended for window gardens and for corridors, or porches and verandas, they should get enough sunlight and some good protection from strong wind and intense sunlight.

USES OF BEGONIA

The begonias are exclusively grown for ornamental purposes, although they are sometimes used as green vegetables. The usefulness of begonias for home decoration and for landscaping is measured by the kind and type and their popularity in the locality.

Uses of the climbing types.—Most of the climbing begonias in the Philippines are growing wild in the forest and their value as ornamental plants is not yet appreciated by the public. Because of the nature of their growth habits (Plate 1) these begonias should make a good substitute for the climbing aroids to cover tree trunks in botanical gardens, parks and in landscaping. One advantage of the climbing begonias over the aroids is that they produce flowers throughout the year. Such begonia flowers can be used as cut ones; they remain fresh for five days or more in properly handled flower vases. The young flower buds, like those of the gladiolus flowers, continue to open in flower vases. Some of the climbing types are good for stone walls and pillars that are not so much exposed to sun and dry winds.

Uses of the creeping or hanging type.—The creeping or hanging type of begonia is one of the few house plants well adapted to window gardens. The species and varieties under this type are fairly hardy to adverse conditions and as such they grow well in crevices or on moist rocks with little soil. They are therefore well fitted for rock gardens with ferns under partial shade of trees. The viny stems of this type of begonia add effect to the decoration of flower baskets for different occasions. Potted plants of this type when hung above windows and porches are indeed very impressive because of their flowers and reddish metallic leaves. They are the most popular among the begonias in the Islands for such a purpose.

Uses of the tree begonias.—For home decoration, the tall kinds are exceptionally fitted as potted plants flanking main entrances to buildings because of their big panicles of attractive pendant flowers (Plate 3, figs. 1 and 2). The long branches full of flowers can be so adjusted as to form an arch, or they can be made to follow a wire above the window porch. When in bloom the bright metallic flowers look like "arañas" when viewed from the outside. To some extent, they can also be used for foundation plantings of concrete or stone stairs and mixed with ferns, variegated sansevieras, calathea, spathophyllum, and the like, as corner plantings of homes. They are

also good for filling up ground spaces under big trees where they can receive enough sunlight (Plate 17, figs. 1 and 2).

The flowers of the tall kinds, as already stated, are in big panicles and of various colors. They are good sources of cut flowers for the table and for decorating flower baskets for special purposes. Cut flowers of this begonia, under ordinary room temperature, without their stems being immersed in water, remain fresh for almost 48 hours.

The dwarf varieties of the tree type are best fitted as potted plants for window gardens, stair-steps, table and other inside decorations in the living as well as in the sleeping rooms; they are rather hardy unlike the Rex or decorative type.

Uses of the Rex or decorative type.—The pleasure and contentment derived from growing begonias under this group is in the beauty of the foliage rather than in the flowers (Plates 9 to 13). Owing to the fact that most of the varieties under this type are delicate, they have very limited use for home decoration. Their place as a rule is in the greenhouse. To a limited extent, they may be used for window or veranda garden if it is possible to arrange that they receive the ideal amount of light, particularly on the north and east exposure. There are a few varieties of the decorative type, such as King, Queen of all begonias, Begonia de Calabasa, Giant and the Baguio varieties that are quite resistant to rain. These can be good for rock gardens under trees and similar conditions where they can enjoy partial shade.

The cut leaves of the decorative begonias, because of their unique beauty and color combinations, should be valuable materials for various decorative purposes. In the making of wreaths of flower baskets, next in importance to beauty and to the design is the element of color and combination. The right use of leaves to match with the color of the mass of flowers as well as the background contributes no little influence in catching the fancy of the people. The begonia leaves do not wilt easily, and the addition of such a decorative leaf to a wreath or flower basket will lend a finishing touch that will greatly enhance its beauty and attractiveness. In beauty and effectiveness, begonia leaves are superior to other leaves of decorative value for decorating dining tables and flower baskets. Rarity and beauty are combinations in decorative materials highly desired in special occasions and the leaves of the Rex type of begonia very handily answer this need.

Other uses.—As has already been stated, some of the begonias can be used as green vegetables. The tender leaves, stems, and flowers are edible. They are tender and palatable and slightly sour like talinum, *Talinum triangulare* Willd., and the young fruits of pias, *Averrhoa balimbi* L. The begonia, however, is not slimy like talinum and for that matter it makes a good substitute for tomato and other sour things in cooking fish and the like. That "the acid stem of various species of begonia are eaten as a flavoring with meat and fish", is the claim of some authorities. It is further claimed that "the stalks of some of the species are used in the same way that the leaf stalks of rhubard are used." Some species are astringent and are used in the treatment of cases of certain fevers in South America and of syphilis. Some species also contain some purgative principles. All the varieties listed in appendixes I and II are edible.

PESTS AND DISEASES

The begonias like any other economic plant have a number of pests and diseases. However, the writer does not know of any of the present pests and diseases of begonias in the Philippines that have been studied.

Pests.—The principal pests of the begonias are worms, and from observations these worms feed on begonia as a secondary host. They are common on different species of gabi including the ornamentals; on the roses, *Rosa* spp.; melindres, *Lagerstroemia indica* Linn., *Anthurium crystallinum,* and others. These larvae, as a rule, are thickly covered with long or short itchy hairs of various colors. Some slug caterpillars also feed on some of the begonias. These insect pests are most serious to the decorative type. They eat the leaf at any stage, but more particularly the tender young ones including the bud. When these are serious, it is not uncommon to see the begonia plants reduced to mere skeleton, leaving only the large veins, petioles and stem of the plant.

Other insect pests found on begonias are some bugs, a species of a bluish green beetle, some scale insects, aphids, and others. So far, these are considered minor pests.

Most of the insect pests of begonias can be easily killed by arsenical or soap solution sprays and by derris powder. For the present, however, due to the lack of some definite information on the use of standard insecticides on begonias, hand-picking of the larvae and killing the adults are perhaps the most

practical and economical way of controlling them. The worms of these insects are readily seen, early in the morning and late in the afternoon. The surroundings of the greenhouse should be kept clean so as to exclude possible places of the moths. Overcrowding of the pots or plants should be avoided so that the insects can be more easily detected.

The earthworm is an enemy of the begonia in the sense that its secreta are deposited along the sides of the pots resulting to poor drainage. If this happens and is not promptly remedied, some of the roots decay and the plant will finally lose vigor. To free the soil from earthworm, it should be sterilized before putting it in the pot.

Diseases.—The most important disease which presently causes so much trouble in the culture of begonia is the nematode root-knot. According to Dr. G. O. Ocfemia, head of the pathology department of the College of Agriculture at Los Baños, the nematode is indirectly responsible for the leaf spot and other diseases of begonias. The infection by root-knot begins with old begonias by the formation of root-knotlike structures on the roots of the plant; this is followed by decay on the roots and even the stem: If the attack is serious the plant wilts by the intense heat of the sun and may eventually die.

The root-knot disease is controlled by sterilizing the soil medium, thoroughly cleaning the pots, and propagating only plants absolutely free from the disease.

The brown sunken leaf spot of begonia is quite prevalent among old plants especially during the wet season and when the pots are kept too dump. The lesions were found associated with a certain species of *Gloeosporium*. The causal organism is generally transferred from one plant to another by water splashes and the spread is greatly accelerated if the plants are watered with the use of a rubber hose. Overcrowding of plants also favors the development of the disease. This leaf spot disease is easily recognized by the presence of irregular brown sunken lesions on the leaves. To check its spread it is desirable to cut off and burn all infected leaves. At the same time the plant should be repotted if not badly infected and then isolated, otherwise it should be burned and the soil in the pot sterilized before using it again. All soils and pots for propagation should be sterilized. Propagating materials should be taken only from healthy plants.

Leaf rot is another serious disease of the leaf. This disease is quite common on the decorative type of begonia. The leaf

rot attacks both big and small plants, but is most serious on those in the seedflats shortly after they have appeared above ground. High humidity and high temperature are very favorable for the development of this disease. It is easily recognized by the water-soaked appearance of the leaf and brown discoloration of the leaf veins. A species of bacteria was found associated with the lesions.

The damping-off disease, another serious disease, is only prevalent in the seed beds and in propagation beds. In other words, the attack is confined to small and young plants. Since like the leaf rot, damping-off disease is favored by damp environment, high temperature and close planting, the effect of these two diseases can be greatly minimized by (*a*) providing good drainage, (*b*) regulated watering, (*c*) good aeration, (*d*) proper spacing between seedlings or potted plants, and (*e*) surfacing the seedflat or germinating medium with well-washed river sand or charcoal. Such treatment will reduce the attack of leaf rot and damping-off on begonias.

APPENDIX I

Grouping of the Rex or decorative type of begonia according to hardiness:

1. Hardy varieties:

Baguio	Principe de Kaliz
De Plata	Principe de Rojo
Diamond	Queen of Begonias
Giant	Repollo
King of Begonias	Royal
Principe de Angel	Royal No. 1
Principe de Arana	Royal No. 2
Principe de Asturias	Royal No. 3
Principe de Espada	Royal No. 4
Principe de Gratino	Royal No. 5

2. Medium hardy varieties:

Antigo de Caracol	Gemmata
Bandera Francis	Maria Clara
Bufallow	Merry Widow
De Seda	Plata de Caracol
Cenefa de Caracol	Principe de Negros

3. Delicate varieties:

American Beauty	Maria Louisa
Bandera Africana	Peluz
Bandera Cubana	Pink Caracol
Lady Helen	Principe de Encañanado
Le Claire de Lun	Principe de Oro

NOTE.—All the climbing, hanging or creeping and tree types are hardy.

APPENDIX II

Flower scent of some of the popular or common varieties.

Rex or decorative type:	
American Beauty	Odorless
Antigo de Caracol	Slightly sweet
Bandera Africana	Odorless
Bandera Cubana	Odorless
Bandera Francis	Slightly sweet
Bufallow	Odorless
Cenefa de Caracol	Odorless
Conan	Strong pungent
De Plata	Strong sweet odor
De Seda	Slightly sweet
Diamond	Odorless
Gemmata	Odorless
Giant	Slightly sweet
King of Begonias	Odorless
Lady Helen	Odorless
Le Claire de Lun	Pungent
Maria Clara	Slightly sweet
Maria Louisa	Slightly sweet
Merry Widow	Odorless
Peluz	Odorless
Pink Caracol	Faint odor
Plata de Caracol	Odorless
Principe de Angel	Odorless
Principe de Araña	Pungent
Principe de Asturias	Slightly pungent
Principe de Espada	Pungent
Principe de Gratino	Slightly sweet
Principe de Incañanado	Odorless
Principe de Kalis	Slightly pungent
Principe de Negros	Pungent
Principe de Puñal	Pungent
Principe de Rojo	Pungent
Queen of Begonias	Odorless
Royal	Slightly sweet
Royal No. 1	Slightly sweet
Royal No. 2	Pungent
Royal No. 3	Pungent
Royal No. 4	Odorless
Tree type:	
Principe de Mano	Pungent
Tree de plata	Odorless
Tree de Peluz	Odorless
Australian No. 1	Odorless
Australian No. 2	Odorless
Australian No. 3	Odorless
Creeping type:	
Gray No. 1 (Pongol Bato)	Odorless
Red No. 2 (Big-leafed)	Odorless

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ILLUSTRATIONS

PLATE 1

General view of the broad-leafed climbing type of begonia in its natural habitat, Trinidad Valley, Mt. Province, Philippines. Note the big flower panicle.

PLATE 2

Different kinds of creeping or sprawling type of begonia.

FIG. 1. Pongol de Bato (gray-leafed, left and right; and red-leafed Pongol de Bato, middle).
2. Seedling variety (a suspected natural hybrid between Gray Pongol de Bato and Red Pongol de Bato).

PLATE 3

Different kinds of tree begonias, tall type.

FIG. 1. Australian.
2. Bengala.

PLATE 4

Different kinds of tree begonias, dwarf type.

FIG. 1. Conchita.
2. Principe de Lantin.
3. Principe de Mano.

PLATE 5

Different kinds of Rex or decorative type.

FIG. 1. Repollo.
2. Rex No. 1 or Royal No. 1.
3. Giant.

PLATE 6

Different kinds of Rex or decorative begonias.

FIG. 1. B. P. I. (Bureau of Plant Industry) No. 1 produced as a seedling variety from Royal.
2. Royal.
3. A group of common varieties of decorative begonias.

PLATE 7

Branches of some popular varieties of flowering or tree begonias.

FIG. 1. Tree de Plata; dwarf variety.
2. Conchita; dwarf variety.
3. Principe de Lantin; dwarf variety.
4. Australian; tall variety.
5. Brazilian; tall variety.

PLATE 8

Leaf specimens of some representative varieties of decorative or fancy type of begonia.

FIG. 1. *a*, B. P. I. No. 1; *b*, Royal; *c*, Principe de Diamante; *d*, Principe de Rojo; *e*, De Plata.
2. *a*, Pink Caracol; *b*, Pink de Plata; *c*, Plata caracol; *d*, Bandera Africana.
3. Hardy varieties: *a*, Principe de Araña; *b*, Principe de Platino; *c*, Giant; *d*, Sperma; *e*, Royal No. 2; *f*, Royal No. 1.

PLATE 9

Some potted plants of the popular but delicate varieties of the decorative type.

FIG. 1. Bandera Africana.
2. Bandera Cubana.
3. Bandera Francis.
4. Plata Caracol.

PLATE 10

Some potted plants of the popular and common varieties of the decorative type.

FIG. 1. Principe de Rojo.
2. Principe de Platino.
3. Royal.
4. Principe de Negros.

PLATE 11

Some potted plants of the popular rare varieties.

FIG. 1. Pink Caracol.
2. Gemmata.

PLATE 12

Some potted plants of the popular rare varieties.

FIG. 1. Principe de Encañanado.
2. Pink de Plata.
3. Green Caracol.

PLATE 13

A general view or group of some rare varieties of the decorative type. *a*, Principe de Encañanado; *b*, Pink Caracol; *c*, Bandera Africana; *d*, Gemmata.

PLATE 14

General view of sprouting leaves and young plants of decorative type of begonia under an avocado plant.

PLATE 15

Leaf cutting of begonia.

FIG. 1. Sections of a leaf and young plants produced from them. Note the size of the young plants.

2. Whole leaves with two to three centimeters of their petioles and young plants produced from them. Note the size and vigor of the young plants.

PLATE 16

Some begonia leaf cuttings.

FIG. 1. *a*, *b*, *c*, *d*, Whole leaves with entire petiole and young plants produced from them.

2. *a*, *b*, Whole leaves as in 1 but the petioles were split and young plants produced from them. Note how the young plants are produced at the bases and sides of the petioles and also note the size, vigor and the number of young plants produced from them.

PLATE 17

Some begonia plants for landscaping, planted together with some balsam under big trees in the Forestry Nursery (Baguio City, Philippines).

FIG. 1. Dwarf tree type—Principe de Mano. Note that the begonias are at the center.

2. Tall tree type used as bedding in terraces with white Amaryllis. The begonias (Brazilian variety) are at the right. Note the beauty of their flowers.

PLATE 18

A method of sprouting or "germinating" begonia leaf cuttings.

FIG. 1. How to plant the leaf cuttings planted in pure well-washed medium of river sand.

2. Sprouting leaves of the decorative type of begonias planted in well-decomposed peat soil.

PLATE 1

PLATE 2

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PLATE 3

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PLATE 4

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PLATE 5

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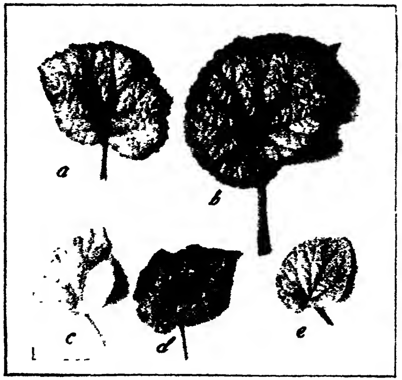
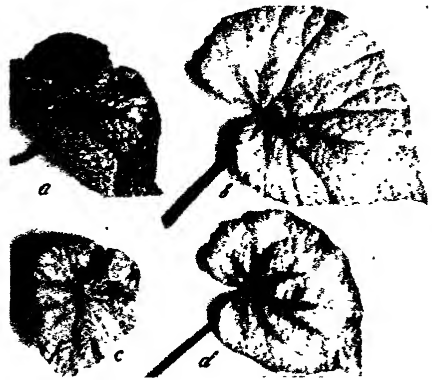
PLATE 6

PLATE 7





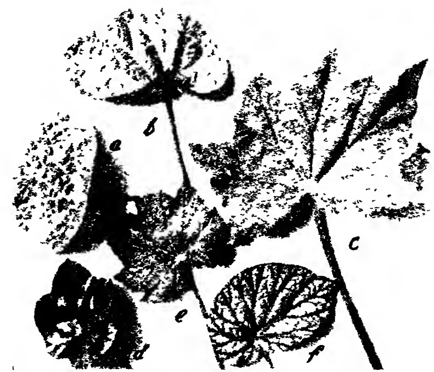


PLATE 8

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PLATE 9

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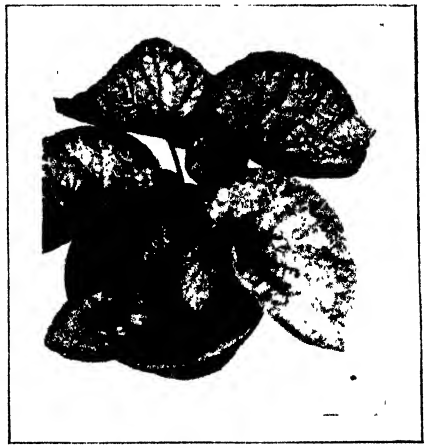

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PLATE 10

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PLATE 11

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PLATE 12

PLATE 14

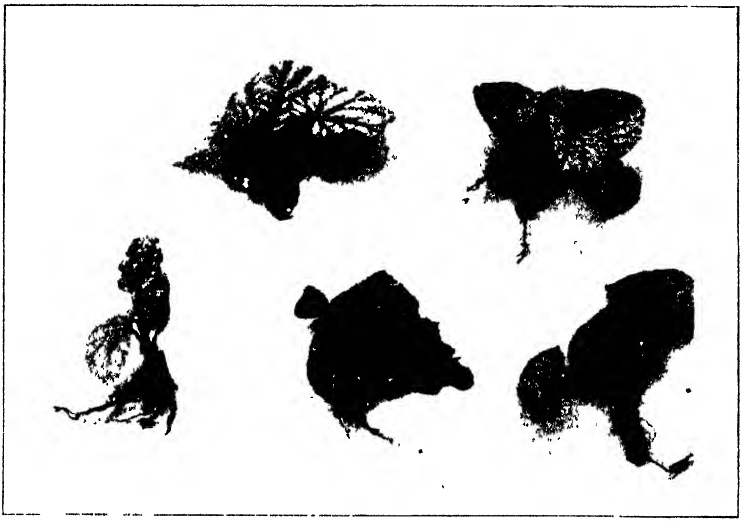

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PLATE 15

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PLATE 16

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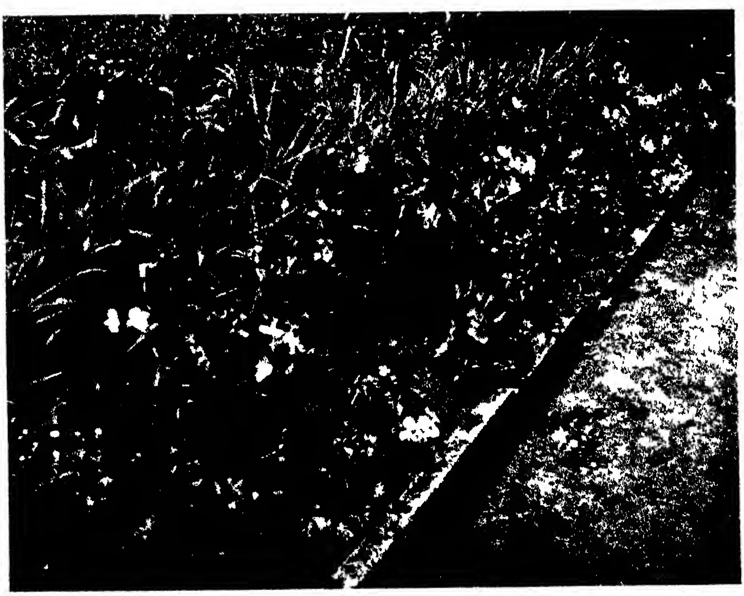

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PLATE 17

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PLATE 18

RESULTS OF A ONE-YEAR VARIETY TEST OF CIGAR FILLER TYPE OF TOBACCO AT LOS BAÑOS, LAGUNA

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One of the factors that reduce cost of production of tobacco crop is the use of seeds of a high-yielding variety. The yield of a crop above or below a certain amount oftentimes is sufficient to determine whether that crop is produced at a profit or at a loss. On this basis, the Tobacco Research Section of the Bureau of Plant Industry attempts to conduct variety tests of the filler type of tobacco in different places in order to determine the highest-yielding tobacco variety to be grown in the locality.

This paper presents the results of a one-year field study of nine different tobacco varieties. Three of these varieties were imported from the United States and the rest are the so-called native tobacco varieties which are generally grown and which have been observed to be highly productive under Cagayan Valley conditions. The test was conducted in the Bureau of Plant Industry Economic Garden in Los Baños, Laguna Province, during the 1938–1939 tobacco season.

MATERIALS AND METHODS USED

The tobacco varieties studied were Simmaba, Vizcaya, Pampano, Repollo, Espada, Romero, Havana, Connecticut, and Jamaica. The last three varieties were imported from the United States. The rest are native varieties from the Cagayan Valley.

Simmaba, Vizcaya, Pampano, Repollo, Romero, and Espada.—These tobacco varieties were described by Paguirigan and Tugade(3) as follows:

These varieties are late maturing. They are commonly characterized by their very rank growth (tall to very tall), large to very large stalks and their numerous, large to very large, coarse-veined, sessile leaves which are either horizontal or drooping with reference to their position on the stalk. The Simmaba is easily recognized by having the broadest leaves which are almost erect in position. The internodes are short. The Vizcaya has broadly elliptical horizontal leaves and long internodes;—the Pampano has horizontal, undulating, broadly ovate dark green leaves;

the Repollo erect medium elliptical leaves; and the Espada very narrow or lanceolate leaves.

Romero.—Variety Romero was characterized by Paguirigan(2) by its medium height, large stalk and its few, horizontal, broadly ovate, petiolate and medium-sized leaves. It has aromatic leaves but because the color is too dark for cigarette filler type standard, he placed the Romero variety under the miscellaneous type of tobacco.

Havana.—Variety Havana was imported from the United States in 1919, and was first tried in Ilagan, Isabela, before it was also grown in the Economic Garden in Los Baños, Laguna. It is characterized by its medium height, and its fair horizontal, ovate, fine-veined, sessile, medium-sized leaves. In Cuba it is grown as a dual-purpose variety, for wrapper and filler, but under Philippine conditions it is more inclined to be a cigar filler variety.

Connecticut.—The variety Connecticut was imported from the United States in 1921, and was first tried in Ilagan, Isabela; then it was grown later in the Economic Garden. It is a tall variety with stocky stems, many medium-fine veined, ovate, sessile leaves attached horizontally to the stem. It matures late. It is more of the cigar filler type of tobacco.

Jamaica.—The variety Jamaica was imported from the United States in 1933, and was grown first in the Economic Garden. Jamaica has the characteristic of the cigar filler type of tobacco, being tall, stocky, with many large accuminate, ovate, rather coarse-veined leaves attached almost horizontally to the stalk. It is late maturing.

Production of seedlings.—Sufficient seeds of tobacco varieties, such as Simmaba, Vizcaya, Pampano, Repollo, Espada, Romero, Havana, Connecticut, and Jamaica, were secured. On October 6, 1938 the seeds were sown in separate seedbeds previously prepared for the purpose. Later the tobacco seedlings were pricked into other well-prepared seedbeds and were allowed to grow there until the young tobacco plants had attained the length of the biggest leaf of 10 to 18 cm.(4) The seedlings were transplanted in the field on December 8, 1938.

The field.—A fairly level field of loamy soil in the Economic Garden was selected. Five blocks, 8.8 meters long and 8.4 meters wide each, were laid out. On October 8, 1938, the field was plowed and harrowed. The operation was repeated three times after intervals of fifteen days.

On December 8, 1938, eleven rows, 80 centimeters apart, were laid in the blocks and planted at random to tobacco seedlings spaced 70 centimeters apart in the row. The border rows of tobacco plants in each of the blocks were not included in the computation of results. The remaining nine rows in the block contained ten tobacco plants each. Each row represented a variety and was replicated five times.

Care of culture.—The soil was cultivated twice with native plow before the plants attained a height of 45 centimeters after which, weeding was accomplished with the use of hoes. Search for worms was made regularly every morning and afternoon during the vegetative stage until the leaves were harvested.

Field observation.—After all the standard leaves had been harvested, the height of each of the fifty plants grown of each variety was taken from a point near the base of the stem of the tobacco plant on the surface of the ground to the tip of the inflorescence. The biggest leaf of each plant, while it was still fresh, was determined during the first priming of the standard leaves and its length and width were measured. The length taken was from the base of the petiole to the tip of the leaf, and the width, at its widest part. The breadth index was then computed by dividing the breadth by the length and multiplying the quotient by 100. The number of standard leaves was recorded at every harvest.

Harvesting.—The method of harvesting the leaves was similar in important essentials to the current practices for filler tobacco in this country. The leaves were primed as they matured. Top leaves were also harvested and their weight was included in the computation of the total harvest.

RESULTS

The results are presented in Tables 1 and 2. Table 1 shows the average measurements of height, length and width of biggest leaf, breadth index and number of standard leaves. Table 2 shows the total weight of cured tobacco leaves harvested from ten plants of each of the nine tobacco varieties. The yield of each variety in every block or replication was given and an analysis of variance made in accordance with Fisher's method. The results of this analysis are given in Table 3. Table 4 shows rank of varieties tested and the differences in yields between any two tobacco varieties including the significance or insignificance of a given difference.

TABLE 1.—*Average height of plants, length and width of biggest leaf, and number of standard leaves of ten tobacco plants.*

Variety	Replication	Height	Measurement of biggest leaf		Breadth index	Number of standard leaves
			Length	Width		
		cm.	*cm.*	*cm.*	*Per cent*	
Connecticut	1	176.2	66.9	35.0	56.1	16.8
	2	169.8	60.8	32.3	53.7	17.7
	3	135.0	44.1	22.7	50.7	16.9
	4	212.8	66.2	37.8	58.1	17.6
	5	170.2	61.2	31.4	55.1	17.1
Average		172.8 ±8.28	59.8 ±2.78	31.8 ±1.72	54.7 ±0.83	17.2 ±0.12
Havana	1	197.1	58.3	36.5	62.6	16.0
	2	135.0	50.0	29.2	58.3	17.0
	3	151.7	40.2	22.3	58.6	15.0
	4	160.6	44.5	28.2	64.2	15.7
	5	158.2	45.2	27.4	63.4	17.2
Average		160.5 ±6.87	47 6 ±2.08	28.7 ±1.54	61.4 ±0.84	16.2 ±0.28
Jamaica	1	191.2	68.3	33.2	48.2	18.1
	2	189.5	66.2	31.2	46.7	20.0
	3	151.1	51.3	23.7	47.2	19.8
	4	207.6	70.3	37.6	53.1	21.7
	5	182.1	64.2	36.7	49.4	20.2
Average		184.3 ±6.26	64.1 ±2.26	32.5 ±1.67	48.9 ±0.77	19.9 ±0.39
Romero	1	205.8	61.3	37.4	61.0	13.9
	2	198.5	59.8	36.4	60.8	13.9
	3	158.9	51.0	37.7	54.3	16.8
	4	205.4	62.0	36.9	59.7	13.1
	5	194.5	59.3	37.3	59.4	13.9
Average		192.6 ±5.86	58.7 ±1.34	37.1 ±0.16	59.0 ±0.83	14.3 ±0.43
Pampano	1	200.5	62.7	33.4	53.2	25.7
	2	201.3	59.7	33.5	56.1	21.7
	3	188.7	62.3	35.2	56.5	25.0
	4	220.0	63.9	36.9	57.7	24.6
	5	206.5	62.2	34.9	56.1	24.1
Average		203.4 ±3.42	62.2 ±0.46	34.9 ±0.43	55.9 ±0.50	24.2 ±0.46
Simmaba	1	150.6	69.7	35.5	50.9	25.8
	2	240.9	69.5	37.9	54.5	28.5
	3	232.0	60.3	31.2	51.7	24.8
	4	276.3	60.8	36.4	52.5	30.3
	5	230.1	68.0	35.6	52.3	27.7
Average		225.9 ±13.90	67.4 ±1.21	35.3 ±0.75	52.4 ±0.50	27.4 ±0.66
Vizcaya	1	263.2	74.0	32.9	44.5	31.0
	2	257.9	76.5	34.3	44.7	31.6
	3	237.1	66.9	30.2	45.1	36.4
	4	283.8	75.9	34.4	45.7	34.5
	5	264.5	74.0	33.2	44.9	38.3
Average		261.3 ±5.04	73.5 ±1.16	33.0 ±0.51	44.9 ±0.62	33.4 ±0.66
Repollo	1	276.6	68.8	33.0	47.9	29.0
	2	270.0	69.7	34.3	49.3	30.9
	3	286.3	55.0	24.9	45.0	35.0
	4	278.8	70.4	33.5	47.4	32.2
	5	284.5	72.8	35.3	48.5	29.3
Average		279.2 ±1.96	67.3 ±2.18	32.2 ±1.26	47.6 ±0.49	31.3 ±0.74

TABLE 1.—*Average height of plants, length and width of biggest leaf, and number of standard leaves of ten tobacco plants.*—Continued

Variety	Replication	Height	Measurement of biggest leaf		Breadth index	Number of standard leaves
			Length	Width		
Espada	1	263.5	76.1	31.7	41.9	29.4
	2	265.3	75.9	34.3	45.1	31.1
	3	270.1	63.1	25.2	39.9	25.9
	4	274.1	71.1	32.6	43.5	28.2
	5	256.2	73.9	31.7	43.4	27.4
Average		266.8 ±2.05	72.0 ±1.62	31.1 ±1.05	42.8 ±0.59	30.4 ±1.02

TABLE 2.—*Showing total weight in kilograms of cured tobacco leaves from ten plants in Los Baños, Laguna.*

Block number	Connecticut	Havana	Jamaica	Romero	Pampano	Simmaba	Vizcaya	Repollo	Espada
1	0.860	0.95	0.85	0.77	0.97	1.40	1.16	1.09	1.23
2	0.71	0.50	1.14	0.74	1.02	1.88	1.62	1.45	1.63
3	0.74	0.36	0.85	0.70	1.18	1.43	1.53	1.21	1.55
4	1.11	0.45	1.33	0.57	1.07	1.57	1.76	1.36	1.19
5	0.58	0.51	1.31	0.80	1.02	1.64	1.52	1.74	1.72
Average	0.800 ±0.060	0.554 ±0.069	1.096 ±0 072	0.716 ±0.027	1.052 ±0.024	1.584 ±0.057	1.518 ±0.066	1.370 ±0.075	1.446 0.072

TABLE 3.—*Showing analysis of variance.*

Variation due to—	Degrees of freedom	Sum of squares	Mean squares
Blocks	4	0.2169	0.0542
Varieties	8	5.7255	[a] 0.7157
Error	32	1.2577	0.0393
Total	44	7.2001	F=18.21

[a] Highly significant: $F = \frac{0.7157}{0.0393} = 18.21$ surpasses the 1 per cent point 3.12, for 8 and 32 degrees of freedom.

TABLE 4.—*Showing differences between mean yield of varieties.*

Varieties	Connecticut	Havana	Jamaica	Romero	Pampano	Simmaba	Vizcaya	Repollo	Espada	Mean yield (Kg.)	Percentage difference of mean yield from Simmaba
Connecticut		—0.246	0.296	—0.084	0.252	0.784	0.718	0.570	0.664	0.800	—49
Havana	0.246		0.542	0.162	0.498	1.030	0.964	0.816	0.910	0.554	—65
Jamaica	—0.296	—0.542		—0.380	—0.044	0.488	0.422	0.274	0.368	1.096	—31
Romero	0.084	—0.162	0.380		0.336	0.868	0.802	0.654	0.748	0.716	—54
Pampano	—0.252	—0.498	0.044	—0.336		0.532	0.466	0.318	0.412	1.052	—33
Simmaba	—0.784	—1.030	—0.488	—0.868	—0.532		—0.066	—0.214	—0.120	1.584	([a])
Vizcaya	—0.718	—0.964	—0.422	—0.802	—0.466	0.066		—0.148	—0.054	1.518	— 4
Repollo	—0.570	—0.816	—0.274	—0.654	—0.318	0.214	0.148		0.094	1.370	—13
Espada	—0.664	—0.910	—0.368	—0.748	—0.412	0.120	0.054	—0.094		1.464	— 7
Rank	VII	IX	V	VIII	VI	I	II	IV	III		

[a] Standard.

Critical difference "d" : $\begin{cases} 0.322 \text{ for 1 per cent.} \\ 0.245 \text{ for 5 per cent.} \end{cases}$

DISCUSSION OF RESULTS

In the field noticeable differences especially as regards height of plants, size of leaves, and number of standard leaves were observed among the nine tobacco varieties grown as shown in Table 1.

Height of tobacco plants.—The nine different tobacco varieties were found to be all tall growers. The average height ranged from 160.5 ± 6.87 centimeters to 279.2 ± 1.96 centimeters (Table 1). The imported varieties, Connecticut, Havana, and Jamaica, were, however, shorter than the native tobacco varieties. Variety Jamaica grew as high as 184.3 ± 6.26 centimeters; Connecticut, 172.8 ± 8.28 centimeters; and Havana, 160.5 ± 6.87 centimeters. Among the native tobacco varieties. Romero was the shortest, with an average height of 192.6 ± 5.86 centimeters, and variety Repollo the tallest, 279.2 ± 1.96 centimeters. The rest, Pampano, Simmaba, Vizcaya, and Espada, were intermediate.

Size of leaves.—The size of leaf is an important factor in tobacco-leaf production. The standard leaves of the native tobacco varieties, especially those of Vizcaya, Espada, and Simmaba, produced long leaves, 73.5 ± 1.16, 72.0 ± 1.62, and 67.3 ± 2.18 [1] centimeters, respectively. The leaves of the variety Simmaba ranked third in length, but they were broader than either those of Vizcaya or Espada. Simmaba tobacco leaves averaged 35.3 ± 0.75 centimeters wide. Variety Vizcaya ranked second, 33.0 ± 0.51 centimeters; and Espada, third, 31.1 ± 1.05 centimeters. The imported varieties had much shorter leaves than the native tobacco varieties. The variety Havana had the highest breadth index and the variety Espada the lowest, 61.4 ± 0.84 and 42.8 ± 0.59 per cent, respectively.

Number of standard leaves.—The native tobacco varieties, except variety Romero, on the average, produced standard leaves ranging from as many as 24.2 ± 0.46 to as high as 33.4 ± 0.66. Variety Vizcaya ranked first, 33.4 ± 0.66; Repollo, second, 31.3 ± 0.74; Espada third, 30.4 ± 1.02; and Simmaba, fourth 27.4 ± 0.66. Of the imported varieties, Jamaica had the most standard leaves, 19.9 ± 1.38; Connecticut, second, 17.2 ± 0.12; and Havana, the least, 16.2 ± 0.28.

Yield.—As shown in Table 3, the total variance was divided or grouped into three different components, namely, variance due to blocks (the soil used in each replication), variance due

[1] Measurements of fresh tobacco leaves.

to varieties, and variance due to the chance of errors of experiments. According to Fisher,(1) variance due to block is an indication of variation in soil fertility (soil heterogeneity); variance due to varieties is an expression of the inherent differences in the yielding power of the nine tobacco varieties tried; and the variance due to the chance of errors of experiments furnishes a criterion for measuring the significance of the experimental results. In this experiment, as shown in Table 3, column 4, the variance due to blocks and errors, were 0.0542 and 0.0393, respectively. These figures are much lower than the variance due to varieties, 0.7157, showing that the inherent differences between the yielding powers of the nine tobacco varieties had been the controlling factor in the study and not due to differences in soil fertility or to errors in experimentation.

The significance of variance in this study was found to be 18.21 for "F", Table 3. This value, according to Snedecor's table(5) for the value of "F", we find that it surpasses the 1 per cent point, 3.12 for 8 and 32 degrees of freedom. It is, therefore, concluded that the variance due to varieties was significant.

In Fisher's "t" table for 32 degrees of freedom, the critical differences "d" in this experiment are 0.322 and 0.245 for 1 per cent and 5 per cent level, respectively (Table 4). Differences between the yields of any two varieties studied which are as large, or larger than either 0.245 or 0.322 are, according to Fisher, statistically significant, Table 4.

The differences of the mean yields per ten plants between variety Simmaba on the one hand, and varieties Connecticut, Havana, Jamaica, Romero, and Pampano (Table 4) on the other, are higher than either 0.245 or 0.322. It is concluded therefore, that the yield of the variety Simmaba was significantly higher than the yield of any of the varieties Connecticut, Havana, Jamaica, Romero, and Pampano. Although the mean yield of the variety Simmaba was higher than the mean yield of Vizcaya, Repollo, or Espada, the difference is smaller than 0.245. It is, therefore, not statistically significant.

Variety Vizcaya produced a mean yield per ten plants of 1.518 kilograms. This yield is significantly higher than the yield of the varieties Connecticut, Havana, Jamaica, Romero, or Pampano. Although the yield of Vizcaya was higher than that of either the variety Repollo or Espada and lower than that of the variety Simmaba, the difference is not so big as 0.245, which is, therefore, not significant.

The variety Pampano produced a mean yield not significantly higher than the variety Jamaica, and if compared to the other eight varieties studied, the variety Pampano produced a mean yield which is significantly low.

The variety Romero was inferior in yield to any of the varieties, Simmaba, Vizcaya, Repollo, Espada, Pampano, and Jamaica. The differences in their yields are significant. Although the variety Connecticut produced heavier yield than Romero, the difference of their yields is not statistically significant.

The imported varieties Connecticut, Havana, and Jamaica produced yields lower than those produced by native tobacco varieties except the varieties Romero and Pampano, and their yields are significantly low.

The differences of the mean yield of the three imported tobacco varieties are significant, and the variety Jamaica produced the heaviest yield and the variety Havana the poorest.

SUMMARY

1. Nine varieties of the cigar filler type of tobacco, namely, Simmaba, Vizcaya, Pampano, Repollo, Espada, Romero, Havana, Connecticut, and Jamaica grown in Los Baños Economic Garden, Laguna, during the year 1938–1939 tobacco season were studied.

2. Varieties, Romero, and Pampano produced yield much lower than either Simmaba, Vizcaya, Espada or Repollo, the differences in their yields being statistically significant. Romero and Pampano varieties were low with short and few standard leaves (Table 1). On the other hand, variety Simmaba, produced heavier mean yield than either Vizcaya, Espada, or Repollo, but the differences in yield were not big enough to be considered significant. However, Simmaba ranked first in yield, 1.58 kilograms per 10 plants; Vizcaya, second; Espada, third; and Repollo, fourth (Table 2).

3. The imported tobacco varieties Connecticut, Havana and Jamaica, under Los Baños conditions, grew short with few and short standard leaves. The differences in their mean yields were found statistically significant. Variety Jamaica ranked first in yield, 1.096 kilograms per 10 plants; Connecticut, second; and Havana, third. These varieties, however, were inferior in yield to any of the four leading native tobacco varieties; namely, Simmaba, Vizcaya, Espada or Repollo and the mean yield differences were found statistically significant. Under Los Baños, Laguna condition, the variety Simmaba is recommended for planting for the production of cigar filler type of tobacco. Va-

riety Vizcaya is its closest rival and it is also recommended if Simmaba is not available in the locality.

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PEANUT CULTURE IN THE PHILIPPINES[1]

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FOUR PLATES AND TWO TEXT FIGURES

The peanut, *Arachis hypogaea* L., has long been under cultivation in the Philippines. Its culture, perhaps, dates back to the early Spanish colonization in this country. Yet, it is far from being satisfactory—this, in spite of the fact that peanut and its products are an important item of commerce here. As early as 1911 the Philippines imported 842,535 kilograms of nuts and 518,341 liters of peanut oil with an aggregate total value of ₱227,970. From 1921 to 1932 the total peanut import amounted to ₱9,207,113 or an annual average of about ₱767,260. From 1945 to 1947 the annual importations of peanut and its products were worth ₱666,548, ₱284,357, and ₱572,396, respectively.

The cultivation of peanut in the Philippines is widespread. In fact it is grown in all provinces, although more peanut is grown in Ilocos Norte, Pangasinan, the Cagayan Valley and Cotabato. Table 1 gives the total hectarage and production of this crop in the Philippines for the period 1929 to 1939.

TABLE 1.—*Hectarage and total production of peanuts in the Philippines, 1929 to 1939.*

Year	Area planted	Production	Value
	Hectares	*Kilos*	*Pesos*
1929	7,494	4,102,380	575,090.00
1930	7,871	4,249,090	616,170.00
1931	7,659	4,442,390	578,820.00
1932	7,750	4,510,700	478,640.00
1933	6,585	4,184,900	375,800.00
1934	6,441	3,638,680	345,420.00
1935	6,108	3,341,410	316,890.00
1936	6,266	3,674,040	352,560.00
1937	6,366	3,780,410	366,640.00
1938	6,420	3,814,520	362,260.00
1939	12,178	6,528,524	537,777.00
Average	7,376	4,206,095	445,552.00

[1] Farmers' Circular No. 9, revised.

HISTORY

The peanut is a native of Brazil, South America. It is believed that it was carried by early slave ships to Africa whence it was brought to the United States during the early colonial days. The peanut in the Philippines must have been brought into this country by the early Spanish settlers. The peanut is also believed to be indigenous to Madagascar. The Madagascar type has smaller pods, but, generally, it has three to four seeds to the pod, while the Brazilian type has one or two kernels to the pod.

CLIMATIC AND SOIL REQUIREMENTS

Peanut prefers a warm climate and a moderate rainfall during its vegetative growth. It thrives well from sea level to medium altitude, and it can be grown in both the wet and dry seasons. However, a better quality crop can be obtained from dry-season plantings, because the absence of rain affords better curing and drying of the pods. Also, it is easier to harvest a dry-season crop; the pods as a rule adhere to the vines and the soil is not compacted and is free from weeds which are common during the rainy season. On the other hand, harvesting the rainy-season crop is an expensive operation, especially when it is delayed because of wet soil. When this happens many of the pods germinate and the quality of the crop is inferior.

Peanut can be grown under a wide range of soil conditions. The best for peanut, however, is a loam to light sandy loam soil with good drainage and fair fertility. Alluvial soils are excellent for peanut. Heavy soil is not suitable for peanut growing because the digging of the pods would be hard and expensive. A liberal supply of lime and organic matter is desirable for the proper development of the pods. Besides, lime is essential for the proper development of the nitrogen-fixing bacteria.

VARIETIES

A considerable number of varieties are grown in different parts of the Islands as judged from variety names. It is believed, however, that many of these variety names are synonyms. The distinct varieties do not only differ in physical appearance, but also in days to maturity, in ability to yield, and in resistance to pests and diseases.

According to the manner of growth, the peanut may be classified into two types: (1) The bunchy type which grows more or less erect and produces the pods in cluster at the base of the plant. Varieties belonging to this type are, as a rule, earlier-maturing varieties. (2) The runner, or creeping type which has a creeping habit and produces its pods along the lateral vines that touch the ground. To the first type belong such varieties like Spanish, Kinorales, Valencia, Vigan Lupog, Chinese, Cagayan Nos. 1, 2 and 16, Biit, and Tirik; while varieties Virginia Jumbo, Tai Tau, Lemery and Ilocos Natives belong to the second type.

Trade classifies peanuts for commerce, both domestic and foreign, into three main classes based on the size of the kernels:[2]

Class I. *Big-Kernel Type:* Kernels numbering less than 45 per 25 grams (0.88 ounce).

Class II. *Medium-Kernel Type:* Kernels numbering 45 to 54 per 25 grams (0.88 ounce).

Class III. *Small-Kernel Type:* Kernels numbering 55 or more per 25 grams (0.88 ounce).

Each and every one of the three main classes as enumerated above is divided into three grades, the designations, specifications, and requirements of which are set forth in Table 2.

TABLE 2.—*Grades of Philippine peanut, showing designations, specifications, and requirements.*

Grade	Shrivels	Splits	Damaged	Foreign matter	Requirements common to all
	Per cent	*Per cent*	*Per cent*	*Per cent*	
P.I. No. 1	20.0	1.5	2.0	0.2	Moisture not more than 8 per cent, dry, reasonably uniform in size, color, free from mold, weevil and other injurious insects, and with no objectionable odor.
P.I. No. 2	30.0	2.0	3.0	0.4	
P.I. No. 3	40.0	2.5	4.0	0.6	

In connection with the above classification, the following terms will be taken to mean as:

(*a*) Shelled peanut is the whole kernel without the shell, or the kernel removed from the pod. When the word "peanut" alone is mentioned herein, it shall be understood to mean shelled peanut.

(*b*) Unshelled peanut is the unbroken or unopened pod with kernel.

[2] For complete information on the grading of peanut, write to the Bureau of Commerce.

(*c*) Shrivels are immature kernels that had dried up and which are wrinkled or corrugated in shape.

(*d*) Splits are kernels broken or divided in particles, either lengthwise or crosswise.

(*e*) Damaged kernels are discolored ones which have either softened in the process of decay or hardened from the effect of heat or other causes.

(*f*) Foreign matters are particles of dirt, clay, stone, wood, husk or shell or the like.

The big and medium-sized kernels are generally used for roasting, boiling and various forms of confections. Vigan Lupog, Chinese, and Virginia Jumbo are some of the big-kerneled varieties, while Spanish, Valencia, Tirik, and others are of medium-sized nuts. Macapno, San Mateo, Kinorales, and some other varieties are considered small-kerneled varieties.

PROPAGATION

Peanut is commercially propagated by seed, although it can also be grown from cutting. Young cuttings are better than old ones, but even the best plants from cuttings do not produce as much as the plants originating from seeds.

One of the limiting factors in the growing of peanut is the supply of good seed. Being very rich in oil, the peanut seed in storage does not remain viable for a long time, especially under warm and humid region as is obtaining in the Philippines. Proper handling of the seed as well as seed selection therefore is of prime importance not only to get better yielding varieties and strains but also to get properly matured nuts. The fully matured nuts can easily be distinguished soon after harvest and some pain should be taken to select enough pods for seeds purposes. These should be at once cured and dried thoroughly and then properly stored for the next planting season.

In the Philippines, where planting is done by hand, the seed may be planted in the pod or as shelled peanut. Where a mechanical planter is used as is done in the United States, the peanut is first shelled before planting. The unshelled peanut has the following disadvantages: (1) It takes longer time to germinate and the percentage of germination is lower. (2) Since poor seeds cannot be eliminated as is done when shelled, the stand of the resulting plants is uneven. In the case of shelled peanuts, sometimes it is attacked by ants and other insects. Where this is likely to happen, the seed may be

treated with some repellant such as a solution of equal parts of pine tar (never coal tar) and kerosene. The seed just before planting is spread, and the solution is sprinkled sparingly and simultaneously stirring the seed so as to distribute the solution more or less uniformly.

In shelling the peanut, care should be taken so as not to break the tin covering of the seed, otherwise its germinating power will be impaired. Shelling by hand is a very slow process and this single item is one of the most expensive operations in the commercial growing of peanut. In the United States the U. S. Department of Agriculture has developed a sheller which does not destroy the membrane of the seed. The seeds come out like hand-shelled.

The amount needed to plant one hectare ranges from 1.5 to 2 cavans of shelled nuts and from 3 to 6 cavans of unshelled nuts depending of course upon the variety, the distance of planting, and the condition of the seed.

PREPARATION OF THE SOIL

The plant needs a thorough preparation of the soil so as to give the maximum production. First plowing should be done a few weeks before planting, especially when a considerable amount of vegetable matters is to be plowed under. The soil should be plowed to a depth of 6 to 8 inches (15 to 20 centimeters). About three plowings followed by the same number of harrowings will be sufficient generally to put the soil in good tilth for planting.

FERTILIZERS AND LIME

While the plant is a legume, it also requires a fairly rich soil for its full development and production. A reasonable amount of organic matter is essential. Soil too rich in humus and nitrogen is conducive to the production of abundant tops and a large percentage of poorly filled pods. When stable manure is used, it should be applied to the crop planted before the peanut.

Commercial fertilizers rich in phosphorus (P_2O_5) and potash (K_2O) and a little amount of nitrogen is generally profitable when applied at the rate of 300 to 500 kilos per hectare. Because the roots of the peanut do not spread far from the row, the fertilizer is best applied along the rows and below the level of the seeds preferably at planting time.

The use of lime is essential in two ways. First, to "sweeten" the soil in order to take full advantage of the nitrogen-fixing

bacteria. Second, to insure the proper development of the pods. The application of lime at 1,000 to 2,500 kilos per hectare has been found advantageous. The lime if applied should not be spread with commercial fertilizer and manures; it should be spread after plowing and then harrowed in.

Wood ashes also make good fertilizers for peanuts; they contain potash and calcium in appreciable amounts.

SOIL INOCULATION

The peanut, being a legume, is associated with nitrogen-fixing bacteria in its growth and development. Where the nitrogen-fixing bacteria are not present in the soil, inoculating the soil or the peanut seed before planting would be beneficial. Experiments conducted by the Institute for agricultural teachers in Bandoeng, Java, showed a definite advantage of the inoculated plantings over the noninoculated cultures, the difference running as high as 24.5 per cent.

Fortunately, however, most of Philippine soils under cultivation are already inoculated with the strains of the nitrogen-fixing bacteria that live on mungo, cowpea, sitao, and peanut. However, when the peanut does not produce any abundant root nodules on its roots, the soil or the seed should be inoculated in the next planting. This is accomplished either by spreading fine soils from peanut fields known to have grown the plant with abundant nodules over field for peanut, or mix the fine soil with the peanut seed before planting at the rate of about two gantas of the fine soil to a cavan of shelled peanut.

PLANTING

As already stated, there are two planting seasons for peanut in this country, the rainy season (May and June to be harvested in September and October) and the dry season (October to December to be harvested in February, March, and April).

The common method of planting peanut in the Philippines is by hand in furrows of medium depth previously made. In the United States some mechanical devices are utilized very effectively in the planting of peanut, thus reducing to the minimum the man-hour requirement in the production of the crop.

The distance of planting is generally governed by the season and the variety planted. Bushy types as a rule are planted closer than creeping types. Rainy season planting is generally spaced further apart than dry-season planting. The common

distance varies from 70 to 90 centimeters between rows and 20 to 45 centimeters in the row depending upon the number of seeds in the hill. Where the seeds are grouped in the hill, they are generally set further apart than when they are dropped singly. Too close planting often times results to poor pod production.

The depth of planting varies from about three centimeters to about six centimeters. Planting should be shallower in heavy soil than in light soil and the opposite is true in dry soil as compared with soil of abundant moisture.

CARE OF THE CROP

When the soil has been given the necessary thorough preparation and it is not badly infested with weeds, cultivation may be reduced to one or two times only. In other words, cultivation is done to kill weeds and to loosen the soil so as to make it ideal for the development of the pods. When weeds threaten to become a menace, the soil should at once be stirred with the use of surface cultivators so as to eradicate them. Under this condition, cultivation may commence as soon as the rows can be followed. While the plants are still small, frequent shallow cultivation would be practical. In the last cultivation, when the plants are already about 20 to 25 centimeters high, the soil should be worked towards the plant thus forming a sort of a ridge on the row. In this case a bed of loose soil is provided for the development of the pods. At no event should the vines be disturbed after they have begun to "peg" [3] down. Experiments conducted by the author in the College of Agriculture, at Los Baños, Laguna, conclusively showed that ridge cultivation is definitely better than flat cultivation.

HARVESTING AND PRODUCTION

Maturity is indicated by a light yellowing of the foliage, and the darkening of the veins in the inner wall of the husk or shell. The latter is a more dependable indicator of maturity. Bunchy type varieties as a rule, mature earlier than varieties of the creeping type, the former type maturing in from 105 to 130 days depending upon the season, and the latter type, maturing in 150 to 190 days. At least 90 per cent of the pods should be matured when harvesting is done.

[3] The peanut is known to "peg" down when the fertilized pistil elongates and turns down to the soil to form the fruit or pod.

In the case of rainy season crop, harvesting should not be attempted when there is danger of rainy days. Harvesting is hard when the soil is wet, and the cleaning and the curing of the harvest is a big problem. For this reason it would be more practical to plant peanut in sandy loam soils during the rainy season.

In the Philippines the use of harvesting machines for peanut is still unknown unlike in the United States. The common practice, especially when the soil is hard and weedy, is to dig the plants with some digging tools like spading fork, crowbar, and the like. Where the soil is soft, harvesting may be aided with the use of a plow; that is, the row of peanut is plowed and the plants are lifted and shaken by hands. Where the soil is hard, digging with spading fork or other digging tools is generally resorted to. In the dry-season culture, especially when the soil is soft, the plants are simply lifted up by hands. One important thing to remember in this connection is to harvest the crop on time, otherwise if delayed many of the pods will not go with the vines, and may even germinate or rot.

As the crop is being dug, some boys usually gather the harvested plants and bring them to the shade where women and children do the picking of the pods. The picking is done by hand and is accomplished in such a way that the peduncle or peg does not go with the pod. The pods are then washed, the poor and immature ones separated, and the matured and sound pods immediately dried in the sun. This method generally results in the production of many shrinked kernels because of too rapid drying. Through proper curing, as will be discussed later, the above undesirable results can be remedied.

Curing.—Curing as a rule is not practiced in the Philippines. As already stated, the crop is simply dried directly in the sun. Curing, in its strict sense, has the objective of gradually drying the pods in a way that it will not cause any undue and rapid heating. It is for this reason that the pods should not be separated from the vines immediately after harvest so as to enable the slow drying of the pods without heating. The whole process is called curing.

In stacking, bamboo or wooden poles about 3 centimeters in diameter and 1.5 to 1.8 meters tall are used as the core of the stack (text fig. 1). Both ends should be sharpened. These poles are stuck to the ground at a convenient distance and to each two cross pieces of wood about 40 centimeters and at

right angle with each other are nailed a few centimeters above the ground. The peanut vines with their pods still intact, already thoroughly wilted and free from dews, are stacked around the poles with the pods and roots towards the center of the poles. Care should be taken not to stack fresh peanuts or those that are partially wet so as to avoid molding. For convenience, the stacks should be built to about 1.5 meters high

FIG. 1. Pole around which peanuts are to be stacked

and should be properly capped with some straw or cogon to protect the stacked peanuts from the rain (text fig. 2). Normal curing lasts in from two to four weeks depending upon weather conditions. If the peanut is not well stacked and cured, the pods are liable to become discolored, thus lowering their commercial value. If for any reason it is necessary to pick the pods before they are fully cured, as it is now generally done in the Islands, they should not be stored in large quantities. Neither should they be directly dried in the hot sun. They should be spread thinly on a dry floor and stirred from time to time until dry. This method of drying may last about a week depending upon the weather conditions. The final drying which may last two or three days, especially the ones selected for seed, should be done in the open sunshine.

PICKING AND SHELLING

Picking and shelling the pods are two of the most expensive operations in the peanut industry in this country. These operations are done by hand, and until we can successfully use

machinery, they will remain to be the main limiting factors in our big-scale peanut production.

Picking of the pods should be done during bright and hot weather when the vines are brittle. During cool weather the vines are tough and picking is difficult. The marketable pods should at once be separated from the poor ones as they are picked up from the vines. The marketable pods should be free from broken vines, leaves, and other foreign matters.

FIG. 2. Completed stack of peanut.

The native way of shelling the peanut is to press the pods singly between the thumb and the point and middle fingers. The work is generally done by women and old men at night. This method of shelling is indeed very slow, tedious, and expensive for the commercial handling of peanuts. The latest device made by the United States Department of Agriculture for shelling peanut for seed, if it would work as effciently here, as has been reported, should boost the local peanut industry. This "USDA" peanut sheller, as it is called, "is only a little larger than the well-known one-hole hand-operated corn sheller and requires about 1½ horsepowers for its operation. It will turn out in one hour 300 pounds (136 kilos) of shelled nuts, the amount a man can shell by hand in 30 days of 10 hours each. The sheller is simple in its construction, operation, and adjust-

ments. Tests show that seed shelled in this machine and disinfected as recommended to control disease organisms will germinate about as well as hand-shelled seed, even if stored as long as 9 weeks before planting."

Yield.—Like other crops the yields of peanut vary considerably as affected by variety, soil type and fertility, season when planted, method of culture, control of pests and diseases, and other factors. The average yield in the Philippines was 547 kilos per hectare or about 12 cavans of shelled nuts in 1935. A four-year test at the Lamao Experiment Station of different varieties gave the highest yield for San Jose No. 3, 12.69 cavans of kernels per hectare; 12.55 cavans for Spanish; and 11.99 cavans for Tennessee Red. In the Los Baños College of Agriculture, it was reported that Valencia gave an average yield of 26.4 cavans of nuts (1,613 cavans of kernels) per hectare; Red Spanish, 19.4 cavans of nut or 14.74 canvans of kernels; Vigan Lupog, 25 cavans of pods or 18.25 cavans of kernels; and Kinorales, 23.1 cavans of pods or 17.78 cavans of kernels. Of course there are isolated cases where the yield was over 50 cavans of pods per hectare.

USES OF PEANUT

The peanut is a source of nutritious food for man and can be utilized in many different ways. Like soybean, the peanut contains protein that contains the essential elements needed for building up the different tissues of the body. Both the peanut protein and oil are of high-grade quality and readily digestible. Peanut oil is commercially used in packing sardines, for medical emulsion and as a substitute for olive oil, and adulterant of cotton oil for the manufacture of vegetable lard and margarine. The lower grades of oil are utilized for soap and cosmetics. Table 3 gives some idea of the oil content of some Philippine-grown peanuts.

TABLE 3.—*Showing the oil content of peanut varieties studied at the Lamao Experiment Station, 1923–24.*

Variety.	Sample as submitted	Dry basis	Variety.	Sample as submitted	Dry basis
	Per cent	*Per cent*		*Per cent*	*Per cent*
Japanese	56.90	58.80	Kinorales	50.58	54.68
Tennessee Red	56.40	60.07	San Jose No. 3	49.74	53.14
North Carolina Runner	54.37	56.94	Vigan Lupog	49.26	53.11
San Jose No. 1	54.13	58.07	Spanish	47.59	52.04
San Jose No. 2	54.10	58.01	Chinese	47.16	51.37
San Mateo	52.31	56.06	Valencia	44.99	49.08
Zambales	52.01	54.85			

Table 4 shows the nutritive value of two varieties of peanuts grown in the Philippines.

TABLE 4.—*Showing a comparative analysis of two peanut varieties*

Variety.	Ash	Fat	Crude protein	Crude fiber	Nitrogen-free extract	Calorific value/100 grams
Spanish	2.65	51.47	31.68	5.04	3.28	620
Vigan Lupog	2.67	49.62	33.23	6.06	1.09	600

The more common uses of peanut may be listed as follows: Boiled peanut in the pod; roasted peanut, either shelled or in the pod; salted peanut; peanut for various candies and pastries; peanut oil; and peanut butter. Peanut is also being used as a component part or adulterating material for making chocolates, and as substitute for chick pea (garbanzo) or bean for mixing with boiled meat. When peanut oil is extracted from the nuts, peanut meal or cake is obtained as a by-product. The good kind of peanut meal is sometimes used for the manufacture of peanut flour which in turn is used for making bread, biscuits, cakes, and the like, in combination with wheat flour. The peanut flour is rich in protein. The inferior peanut meal is used for livestock feed and for fertilizer.

The peanut vine makes also a very good feed for livestock and is highly relished by cattle and horses. It can be cured into a first-class hay. It compares well with other first-class hay like clover and alfalfa. The creeping varieties with fine and leafy stems are preferred for forage purposes. Table 5 gives some idea as to the comsumption of peanut hay as compared with common hays.

TABLE 5.—*Comparative composition of peanut hay and other feeds.*

Name of feed	Crude protein	Carbo-hydrate	Fat
	Per cent	*Per cent*	*Per cent*
Peanut hay	11.75	46.95	1.84
Peanut (entire plant)	13.84	36.28	15.06
Clover hay	12.84	48.31	2.11
Cowpea	19.72	45.15	4.04
Alfalfa	16.48	42.62	2.03
Timothy	7.17	52.94	1.95

PESTS AND DISEASES

The peanut as grown in the Philippines has a number of enemies, both pests and diseases which at times are quite serious.

Pests.—There are a number of insect pests that attack the peanut. Among these pests may be mentioned the mealy bug, *Pseudococcus* sp.; grubs, *Leucopholis irrorata;* and some caterpillars. At times some of these are serious, particularly the first two, but they seldom become serious in large scale plantings.

Diseases.—Peanut diseases, although fewer in number, have proved to be quite serious and inflict considerable losses on the crop. Black spot and sclerotium wilt are the most important of the diseases.

Black spot.—So-called because of the black spots that are first observed on the leaves. In severe cases the spots become numerous and big, coalescing with one another. Even the vines and the "peg" are attacked, and the plant may get stunted and prematurely die. If the plant does not die, its yielding power is greatly reduced. The disease seems to be more severe during the rainy season. The causal organism is a fungus known in science as *Cercospora personata.* It can be controlled by spraying with Bordeaux mixture and other standard fungicides, but the most effective and practical way to evade the attack of the disease is to use resistant varieties. Fortunately there are some varieties, such as Virginia Jumbo, Tai Tau, and San Jose, that are quite resistant to this disease.

Sclerotium wilt.—This is a soil-borne disease and is quite serious on peanut and other crops. The disease attacks the base of the plant including the "pegs" and ultimately the pods. The diseased portion is easily recognized because of the whitish to brownish mycelia in the stem and pods with plenty of sclerotial bodies. The attacked plants are greatly devitalized and ultimately die. This plant malady is caused by *Sclerotium* sp. Its attack is most severe during damp weather of high temperature. So far, there is no known effective method of suppressing this disease. Pulling off and collecting all infected plants and then burning them will help thwart the spread of the disease. Fields known to be infested with this disease should not be planted to peanut and beans and other crops that are subject to its attack for a number of years. Virginia Jumbo and Tai Tau are known to be resistant to *Sclerotium* wilt and therefore should be preferred to other varieties for planting purposes.

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ILLUSTRATIONS

TEXT FIGURES

PLATE 1

PLATE 2

PLATE 3

PLATE 4

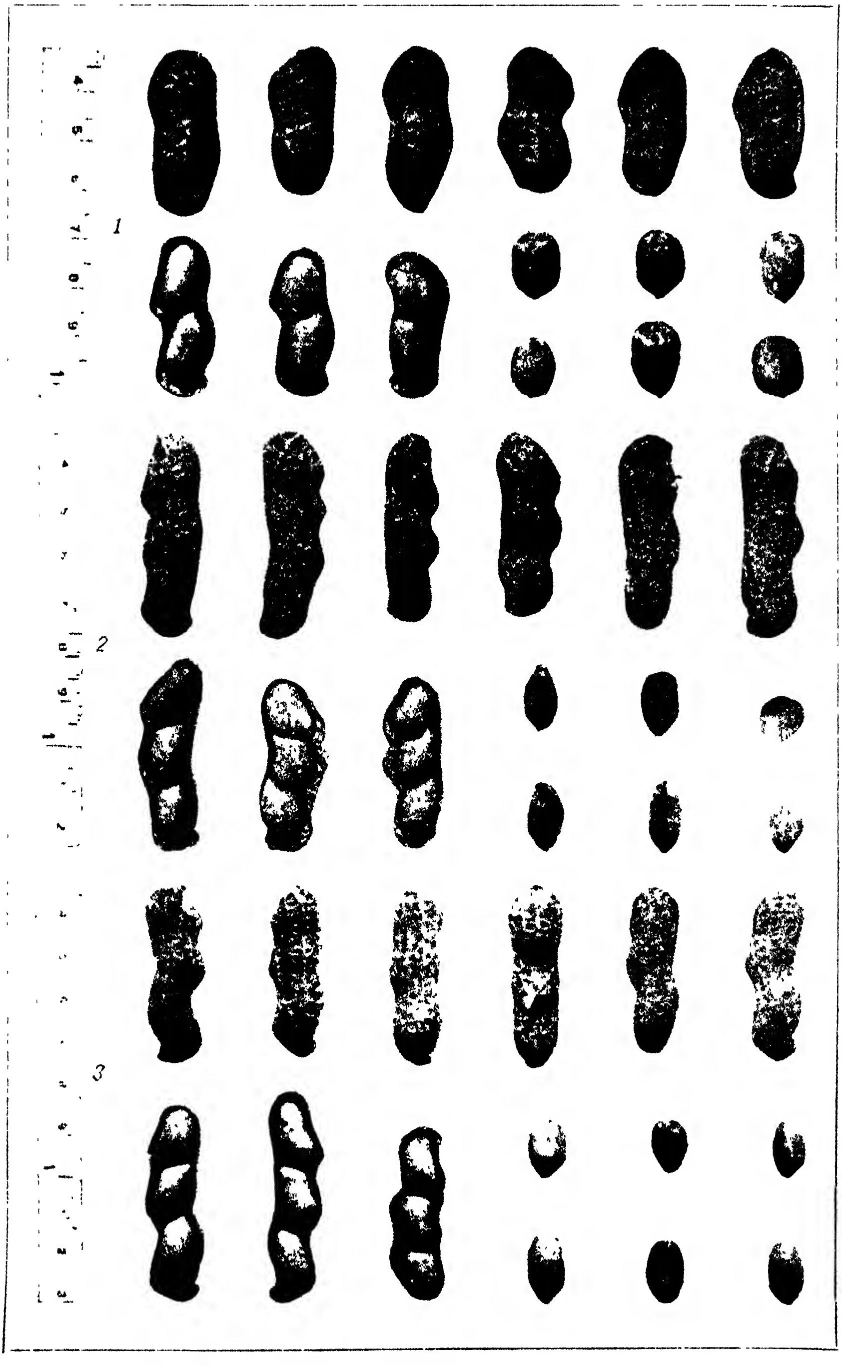

PLATE 1

PLATE 2

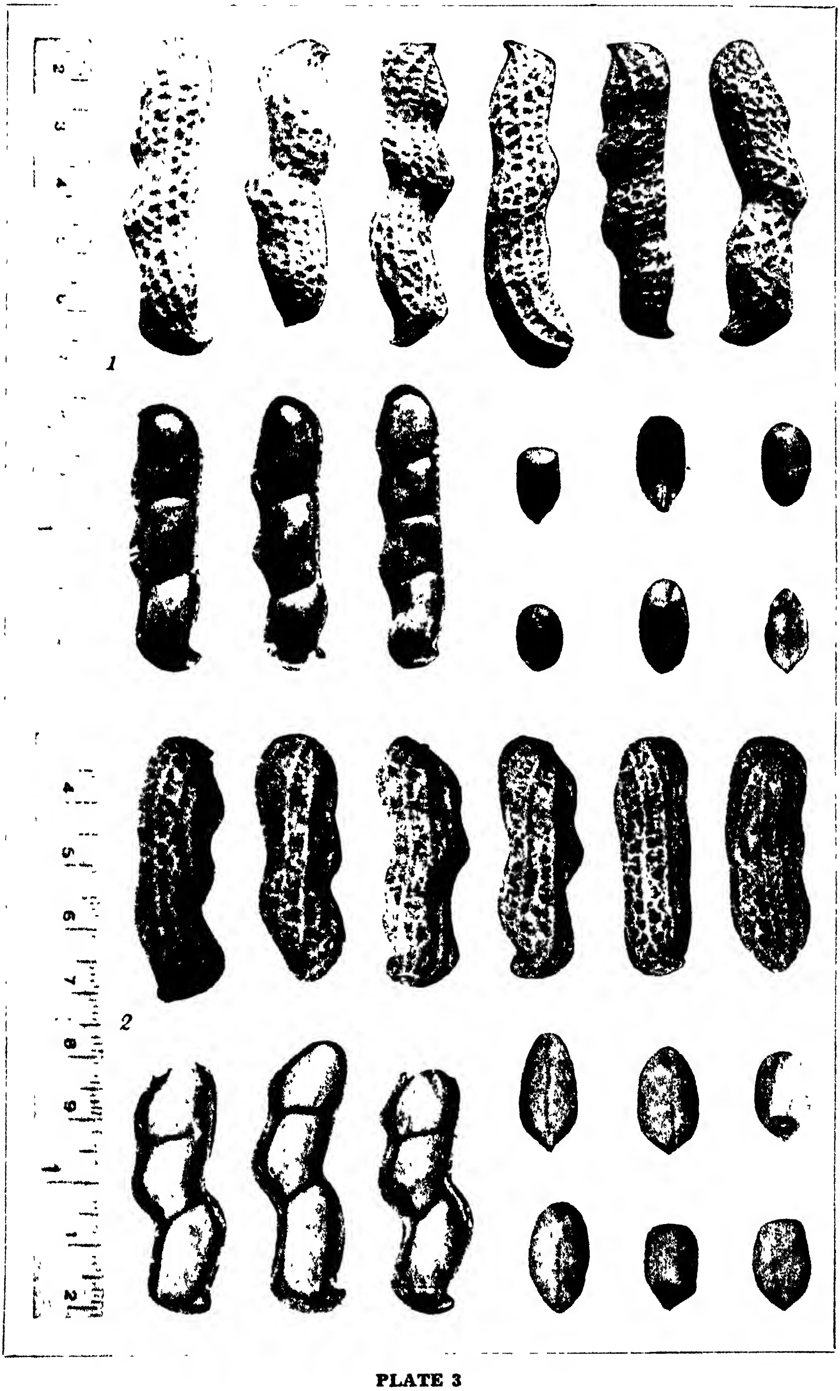

PLATE 3

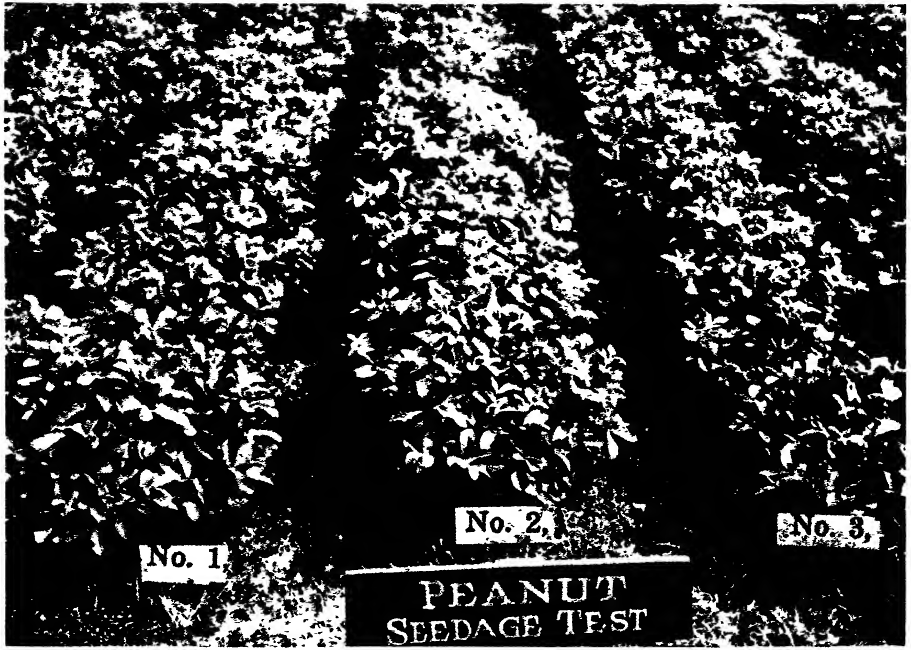

PLATE 4

PRINCIPLES AND DESIGN OF THE RESISTANCE-TYPE SOIL STERILIZER

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TEN TEXT FIGURES

INTRODUCTION

It has been known for a long time that the growth of plants in the soil is very materially improved if harmful organisms present in the soil were killed or otherwise rendered harmless. The process of getting rid of these organisms is called soil disinfection or sterilization, as it is more popularly known. Steam heat and some chemicals are the time-honored agents used for soil disinfections. Recently a new agent has gained popularity for the same purpose, the ever useful electricity.

Disinfestation of soil by electricity has been extensively and intensively investigated during the past several years. A great impetus was given to this field of research when it was discovered that the soil itself could be used as the heating element. Very soon two types of disinfestation by electricity were developed, namely, the resistance type, in which the soil itself is used to conduct the electric current, producing heat by its resistance to the passage of current; and the method in which the conventional metallic heating element is used which is incased either in lead cables or in metallic tubes or pipes provided with a suitable insulating material.

It has been claimed that disinfestation of soil by electricity is as effective as, if not more effective than, that in which steam and chemicals are used: as economical and simpler in operation, readily available and available at all times, and is especially adapted to small growers. However, in spite of these advantages, there are many defects in this method which are as yet not remedied and which prevent its more widespread use by growers in general.

A review of literature on disinfestation of soil by electricity, and soil disinfestation in general, would lead the reader to appreciate the large economy and benefit resulting from this

practice, while, at the same time, it would make him realize the tremendous odds, although not insurmountable ones, which must be overcome in order to perfect this system.

REVIEW OF LITERATURE

Viscount Elveden, M.P., seemed to be the first person to have made intensive investigation on soil disinfestation. Working from 1917 to 1920 he investigated the effect of partial sterilization of soil by moist heat (using steam) on the growth of plants. In this work he was inspired by the discovery of E. J. Russell and H. B. Hutchison in which they claimed that available plant food in the soil is increased by partially sterilizing the soil by heat. Indeed, Viscount Elveden found an average increase in yield of the plants grown in treated soil (that is, partially sterilized) of about 235 per cent above that of the control; for garden soil this increase had a maximum value of 603 per cent and 403 per cent for field soil. This same investigator used electricity [1] for sterilizing, but unfortunately, he did not present any data.

A. G. Newhall, 1930, mentioned that Godfrey and Morita found that larvæ of *Heterodera* are killed instantly at 128° F. and in 10 minutes at 110° F. Egg masses are more resistant, being instantly killed at 137° F., and in 10 minutes at 119° F. In this experiment, the thermal death point for all stages was between 116° and 120° F. in 10 minutes in ordinary loose soil.

L. B. Carney, 1932, reported the following thermal death points for the following organisms:

	°F.
Nematodes	140
Phythium	140
Septoria lycopersici spores (on tomato)	127
Rhizoctonia (on lettuce)	176
Sclerotinia (on lettuce)	176

Working with a heater-type sterilizer at 1 cubic yard capacity he reported the following figures:

Power demand	4.98 kw.[2] (heater in porcelain tubes).
Energy consumption	30 to 35 kwh.[3] per cu. yd.
Time required for sterilization	5½ to 6 hours.

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[1] Scott (1932) mentioned that Charles W. Wildebour had originated the resistance type of sterilizer.

[2] Kw. is the abbreviation for kilowatt.

[3] Kwh. is the abbreviation for kilowatt-hours.

He recommended that the capacity of the heating element should be below 9 watts per square inch of heater surface to prevent scorching of the soil.

J. C. Scott, 1932, working with a resistance-type sterilizer, reported the following:

Power demand (maximum)	7.8 kw.
Energy consumption	350 kwh. for 416 cu. ft. (to 180° F.)

He mentioned that very even distribution of temperature was obtained which is extremely difficult to do by other methods of soil sterilization; danger of severe electric shock is present; it took several hours for the temperature to recede to normal after the current was turned off. He also mentioned identical thermal death points for the organisms cited by Carney.

A. V. Krewatch and Geo. W. Kable, 1933, working on a heater-type sterilizer of 1 cubic yard capacity reported the following figures:

Power demand	5 kw.
Energy consumption	1.2 kwh. per cu. ft. (to 180° F.)

Working on a resistance-type sterilizer (vertical electrode) they reported:

Capacity	7.2 cu. ft.
Power demand	9.0 kw.
Energy consumption	30 to 40 kwh. per cu. yd. for bench sterilizer and 25 to 30 kwh. per cu. yd. for box sterilizer.

They mentioned the uneven heating of the soil in the heater-type sterilizer and danger of shock in the resistance type, besides the large leakage of power to ground in the latter. They obtained even heating in the resistance-type sterilizer, but the soil lumped at high moisture content, and they had to use electrolyte to be able to heat sand; they observed also drying of the soil at the electrodes. They noted the semiautomatic feature of operation of the resistance-type sterilizer.

I. P. Blauser, 1934, working on a resistance-type sterilizer of 5 cubic feet capacity, reported the following figures:

Maximum power demand	50 amperes at 230 volts
Energy consumption	1 kwh. per cu. ft.
Time of heating	1 to 1½ hours to 210° F.

This investigator said that horizontal-electrode sterilizer is simpler, much easier and cheaper to construct than vertical electrode sterilizer.

Heat, he said, is the primary cause of sterilization and not the passage of electricity itself, and that the length of time required to bring the soil up to a temperature of 210° F. or less depends upon the character of the soil, the moisture content, the soluble salts, the distance between the electrodes, the area of soil in contact with the electrodes, and the voltage used.

In the case of soil with a very high specific resistance such as sand, he had to use from 1/40 per cent to 1/20 per cent of ammonium sulphate or potassium chloride to increase the conductivity.

He recommended that the capacity of the available electric service must be considered in order not to overload the transformer and distribution system, and also cautioned that the operator must not touch the soil while the current is on.

L. C. Hervey, 1934, had the following figures to report about a resistance-type sterilizer used in the Rural Electric Project, University of Maryland:

Capacity	7 cu. ft.
Maximum power demand	15 kw.
Energy consumption	1 kwh. per cu. ft.

He said that root-knot, wilt, damp-off, root, stem and crown rots are caused by worms, bacterial fungi, and are always present in soil that is intensely cultivated. These organisms are killed at from 140° F. to 200° F. together with weeds and insect eggs. These disease-producing organisms are also killed by soaking the soil with boiling water but it leaves the soil puddled and difficult to work. Chemicals could also be used but they leave the soil toxic to some plants and do not kill weeds.

He observed that the conductivity of the soil varies with the per cent of soluble salts and per cent of moisture content present in the soil so that the power demand is very variable.

He had difficulty with the drying up of the soil in contact with the electrodes. He also suggested that to prevent the danger of shock, a transformer with a voltage ratio of one to one must be used. He mentioned using electricity to produce steam at 250° F. and this in turn used to sterilize the soil.

G. W. McCuen and I. Blauser, 1934, mentioned the following in connection with the sterilization of soil by electricity: Thorough sterilization is the only sure method of having disease-free and weed-free soil. The amount of current that the soil will carry and the length of time required to bring the soil up to sterilizing temperature depend upon the type of soil, the moisture content, the soluble salts, the voltage and the spacing

of the plates. The amount of electricity required will average about 1 kwh. per cubic foot, depending upon the temperature and the length of time for sterilization.

Anonymous, 1935, writing about sterilization of soil by electricity said, "There is little question as to the value of soil sterilization, consequently this discussion will confine itself to the practicality and feasibility of electricity as a source of energy for the purpose. Sterilization destroys the harmful organisms in the soil, and tends to increase the fertility of the soil and the vigor of the plants."

Citing the work done at the Oklahoma A. and M. College in cooperation with Earl Miller, Research Assistant in Rural Electrification, he said that the killing temperature for most organisms is 180° to 190° F., the energy consumption is one kwh. per cubic foot and that the energy supply came from a 100 ampere switch.

J. G. Horsfall, 1935, working on a heater-type sterilizer (using lead heating cables) with a capacity of 1 cubic yard, reported the following:

Energy consumption	20 kwh. per cu. yd.
Time required	4 hrs. to 105° F.

He said that soil at room temperature and medium wetness, is contaminated with *Phythium ultimum*, the organism responsible for most of the damping-off in the station greenhouses. *Rhizoctonia solani* and *Botylis* sp. also occur in this soil but they are unimportant damping-off pathogens.

Temperatures of 160° F., 140° F., 120° F., and 105° F. killed all harmful and destructive microbes. Tomatoes grew taller, greener, and more vigorous in pasteurized soil. Spinach seeds had a germination of 91.4 per cent in treated soil and 20.5 per cent in untreated. There was 2.5 per cent damped-off in treated and 49.1 per cent in unpasteurized soil. A large number of similar tests gave similar data.

These and dozens of other tests all indicate that soil need not be heated higher than 105° F. before the current is turned off, provided that the soil can be left in the pasteurizer overnight. Steaming soil or "sterilizing it at high temperatures even with electric heat is detrimental to it, as is well known. Steamed soil is darkened in color; plants sown in it immediately may be stunted or even killed, and the soil loses much of its water-holding capacity.

A. G. Newhall and M. W. Nixon, 1935, reported the results of an intensive study of the operating characteristics of the

two types of portable electric soil pasteurizer. They summarized their conclusions as follows: Both types were found capable of destroying a number of common pathogens, including bacteria, sclerotial fungi, nematodes, and weed seeds. Evidence is presented to show that it is not necessary to raise the soil temperature above 70° C. in the presence of adequate soil moisture to kill several common soil pathogens.

All kinds of soil from pure sand to pure muck were effectively treated in both types of pasteurizer. However, in the direct heating (resistance type) it was often necessary to add some dilute electrolyte solution to sand to insure heating in a reasonable time.

In comparison with other standard methods of soil or seed treatment for damping-off control, electric pasteurization appeared to be equal to the best. For a 50° C. rise in temperature (from initial 20° C. to final 70° C.) from 1 to 1.3 kwh. per cubic foot is required. Where only nematodes and dumping-off organisms are being combated, lower final temperatures are permissible, at a saving of current, if more time is employed.

A certain minimum initial-soil-moisture content was found to be very important for most effective operation of both types of pasteurizer. Factors affecting the uniform temperature rise in different parts of the soil mass included uniform distribution of soil moisture, position in the box, degree of packing, insulation, intimacy of contact with electrodes and speed, or time.

Each type of pasteurizer has its distinct advantages and disadvantages, the sum total of which perhaps favor the New York type (heater-type sterilizer) for general use by the average operator, because of its greater safety and simpler operation.

Among the disadvantages Newhall and Nixon found in the resistance-type sterilizer are high power demand, 7 kw. for a capacity of about 2 cubic feet, temperature lag at moderately high moisture content, inability to use sand without using electrolyte and danger of shock. In the heater-type sterilizer the temperature distribution was very uneven, and to get a fairly low maximum temperature a large moisture content is necessary, otherwise the maximum temperature reaches as high as 250° C.

They reached the conclusion that 70° C. is enough to kill almost all harmful organisms, and that 60° C., or even lower, would be enough if only damping-off fungi are present.

J. R. Tavernetti, 1935, working on a multi-electrode, resistance-type sterilizer reported the following: Energy required for heating from 50° F. to 212° F. varied from 2.20 to 3.39 kwh. per 100 lbs. of dry soil with 14 per cent and 27.5 per cent moisture content, respectively. The heating time varies inversely as the square of the voltage, and the current directly with the voltage. This type of sterilizer has the advantage of simple and inexpensive equipment, easy and speedy operation, uniform heating and semiautomatic operation. Its disadvantages, however, are hazard from an electric shock, inability to heat soil of low moisture content and of high specific resistance, and variable electrical load. The power demand of the sterilizer varies widely, depending mainly upon the electrolytes in the soil, distance between electrodes, soil density and moisture content. With one soil, the current may exceed the capacity of the line, with another the current may be so low that the heating time will be excessive.

The data used and discussed in this paper were gathered by the writer when he was working for his master's degree at Cornell University in 1939. There are two reasons why this present discussion could not be included in his master's thesis: Firstly, that he did not have sufficient background and practice in statistical and mathematical analysis as applied to scientific research (particularly in curve fitting); and secondly, even if he did have the background and the practice, he would not have the time to treat his data as they are now treated, because the treatment is time-consuming and laborious.

A brief description of the technical background and of the experiments performed to gather the above-mentioned data are necessary in order for the reader to have a clear understanding of the subsequent discussions.

There are two types of electric soil sterilizer. One type is the heater type developed in Cornell University, and the other is the resistance type invented and developed in Ohio State University. In the first type the soil to be sterilized is heated by a metallic heating element suitably mounted and insulated, while in the second type no heating element is used, because the soil itself acts as the heating element. Fig. 1 shows the schematic diagrams of the two types of electric soil sterilizer.

The advantages and disadvantages of the electric soil sterilizer as compared to other methods of soil sterilization (chemical and steam sterilization) are as follows:

Advantages.—(1) Simple construction (resistance type especially), (2) economical, (3) effectiveness, (4) semiautomatic operation (resistance type), and (5) more uniform temperature distribution (especially in resistance type).

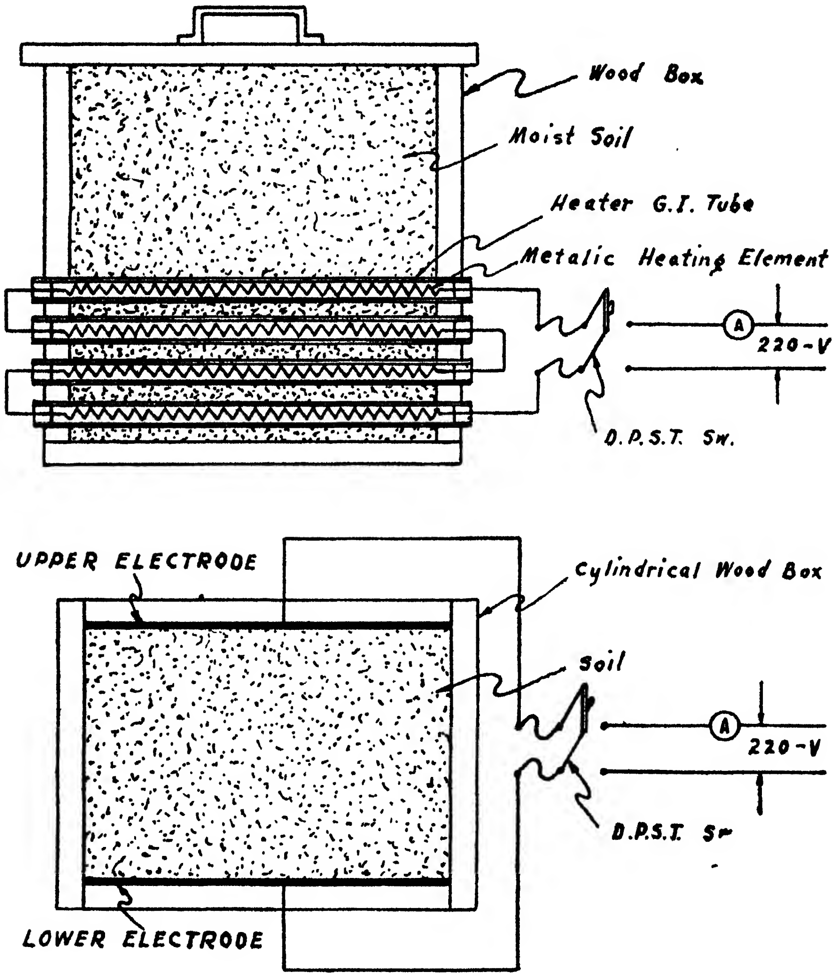

FIG. 1. Types of electric soil sterilizer.

Disadvantages.—(1) High maximum temperatures at moderately low moisture content (heater type), (2) variable load and high maximum power demand (resistance type), (3) inability to sterilize soil of high specific resistance, such as sand, without the addition of certain electrolytes (resistance type), and (4) danger of shock (in resistance type).

In view of the above considerations, the writer planned to evolve a method of soil sterilization by electricity in which the simplicity, the semiautomatic action, and the uniform temperature distribution of the resistance-type sterilizer would be retained, but at the same time eliminating the danger of shock, the high maximum power demand, and inability to heat the soil of high specific resistance. He proposed to use, as a source of electrical energy, the so-called constant-current transformer which is generally used for series lighting of streets in almost every city of moderate size throughout the world. This piece of apparatus was expected to eliminate the danger of shock, because its secondary winding is well-insulated from the ground; it would eliminate the high-power demand, because it cannot deliver more power than its rated capacity no matter what the load impedance might be; it would eliminate the inability to heat soil of specific resistance, because it can develop a voltage much higher than the usual 220-volt, 60-cycle supply.

In addition to the above, the writer hoped that because of the higher voltage developed by this transformer, the moisture content of the soil to be sterilized could be decreased to a lower value. The importance of this could be appreciated by the following considerations:

Let M = mass of the soil to be sterilized in lbs.;
K = per cent moisture content (dry basis);
Δt = temperature rise in Fahrenheit degrees;
H = total heat added to the soil in B. T. U.;
S = specific heat of water; and
S' = specific heat of the soil

Then $$H = MS'(\Delta t) + 0.01KMS(\Delta t) \qquad (1)$$

It is known that $S = 1$
and $S' = 0.2$ (average value)
Therefore $$H = 0.2\,M(\Delta t) + 0.01\,KM(\Delta t) \qquad (2)$$
Let $M = 100$ lbs.
$K = 20$ per cent
$\Delta t = 90°$ Fahrenheit (adequate value)

Substituting these values in (2), we have

$$H = 0.2\,(100)\,(90) + 0.01\,(20)\,(100)\,(90)$$
$= 3600$ B.T.U., or 1.055 kwh. (1 kwh. = 3416 B.T.U.).

In some cases $K = 100$ per cent or more.
Hence $$H = 0.2\,(100)\,(90) + 0.01\,(100)\,(100)\,(90)$$
$= 10{,}800$ B.T.U., or 3.17 kwh.

From the above consideration it can clearly be seen that the total amount of heat required to sterilize the soil by the present method is used up largely by the moisture in the soil—50

per cent of the total heat is used up by the water in the first example and 83.33 per cent in the second. Table 1 (at the end) shows the amount of heat required to raise 100 lbs. of soil 90° Fahrenheit (= 50° Centigrade) at different moisture contents, and also the amounts used by the soil and moisture respectively. From this table it can be seen very clearly that a very great saving in energy consumption could be effected if soil could be sterilized at low moisture content. It was surprising to note that the relation between moisture content and energy consumption was entirely neglected by previous workers.

Another advantage that could be derived by the use of the constant-current transformer is that the sterilizer would be rendered foolproof as far as overloading the service line is concerned, because no matter what the load might be, from infinite load resistance, that is, open secondary, to dead short-circuit, the power delivered could not exceed the rated transformer capacity.

Objections might be raised, because of the high cost of the transformer (for the same capacity a constant-current transformer costs more than an ordinary constant-voltage power transformer). The writer is aware of this fact, but it is hoped that if it could be demonstrated that sterilization of soil using this method would be advantageous, both economically and operationally, over the present methods, that arrangement could be made whereby scores of constant-current transformers (which are idle during the daytime) in any city, could be relocated so that they would be near the places where they could be used readily for soil sterilization during the day.

METHODS OF INVESTIGATION

Figs. 2a and 2b show the arrangement and wiring diagram of the various electrical apparatus used in the experiment. The sterilizer was filled to a certain depth with soil (say, sandy loam) containing sufficient moisture to make it drip a little. Sample of the soil was taken little by little while the sterilizer was being filled, to insure that a representative sample was obtained for moisture content determination. This soil sample was kept in a sealed bottle. The surface of the soil was then leveled and the cover placed on it and pressed down by the pressure device to insure intimate contact between the soil and the electrodes. If the soil was quite dry, the electrodes were first moistened by a wet rag.

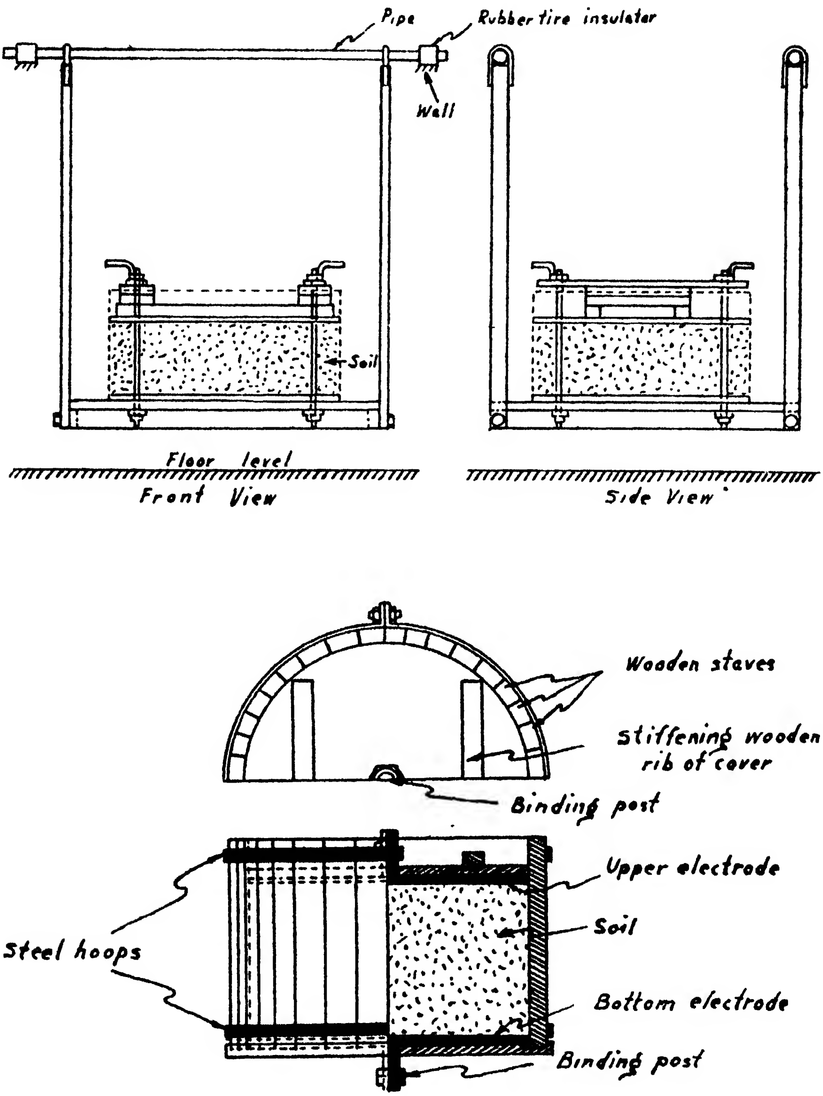

FIG. 2a. Above—Sketch showing assembly of supporting flatform. Outline of sterilizer shown in dotted line in order not to complicate views. Below—Sketch showing details of sterilizer proper.

Thermometers were then inserted as shown in fig. 2. Temperature readings were taken from at least six different places during the progress of a run and in six additional places at the end of the run. For greater depths, temperature readings were taken at nine places during the run in nine additional places at the end of the run.

Before closing the circuit, fig. 2b, the following initial readings were taken and recorded: (1) the initial readings of the thermometers (the soil was usually started at room temperature, about 20° C.); (2) the room temperature; (3) the initial reading of the kwh. meter; and (4) the time at starting.

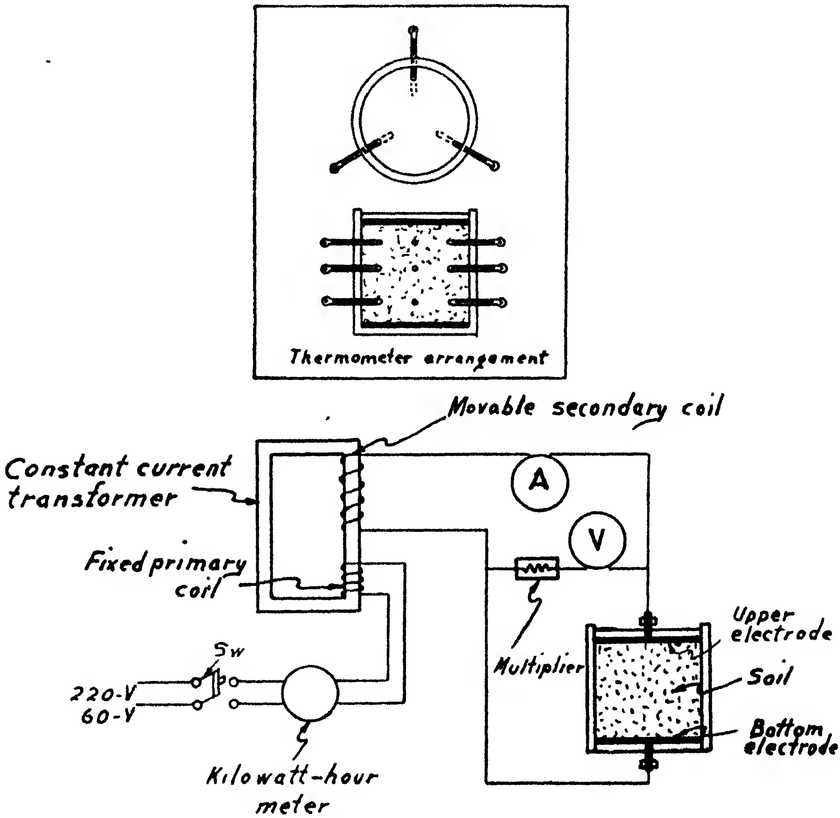

FIG. 2b. Wiring diagram showing connections of the various apparatus.

The switch was then closed and readings of the thermometers, ammeter, voltmeter, and room temperature were taken and recorded at intervals of 5, 10, 15, 20, or 30 minutes, depending upon whether the heating was slow or rapid, until an average final temperature of about 70° C. or more was reached. The switch was then opened and the final reading of the kwh. meter was taken and also the time at the end of the run. The thermometers were then shoved toward the center of the soil

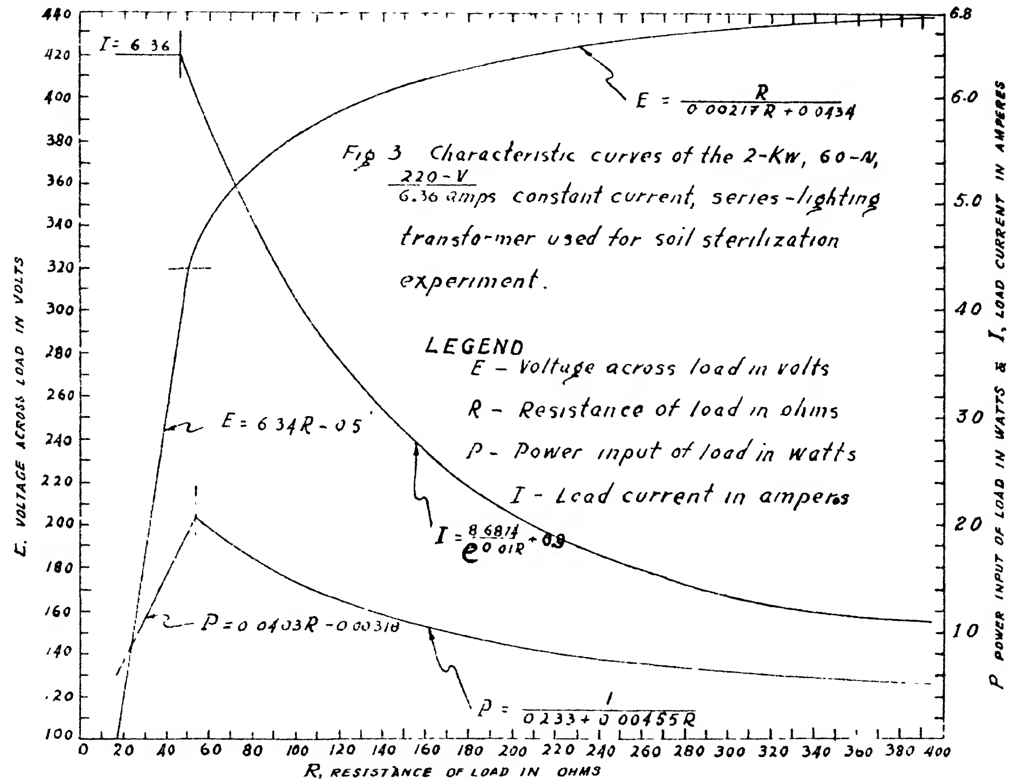

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FIG. 3

as far as they could go and readings taken after a short interval of time.

In between reading periods about 50 grams of soil sample were weighed and placed in the drying oven. The sample remained in the drying oven from two to four days (depending upon the kind of soil, sand requiring the least, and muck the longest time for drying) and dried to constant weight. The difference between the initial and final weights divided by the final weight and multiplied by 100 gives the per cent moisture content of the soil (dry weight basis) for that run.

After the run, if there was time, the soil was discharged and spread on the cement floor of the laboratory. The heat of the soil was usually enough to vaporize some of the moisture content and decrease this a few per cent when the soil attained room temperature again, at which time the soil was put back into the sterilizer and another run was made at this lower moisture content, the depth being maintained almost the same as before.

Repeated runs for a given depth and kind of soil at decreasing moisture content were made until the specific resistance of the soil was increased to such a value that the transformer couldn't develop a high enough wattage to heat the soil within a reasonable length of time.

Another depth was used (usually greater than the preceding one) with enough moisture content so that the soil dripped a little as before. The previous procedure was again followed. In this manner a depth was reached so that even if the soil was saturated, not enough current could flow to heat it to sterilizing temperature in a reasonable length of time. At this juncture the test for the kind of soil in question was considered completed.

The observed data, together with those computed from these, are recorded in 42 tables and graphically represented in 13 charts (in the original thesis). It is of interest to note that the main objectives of the investigation had been attained. These are simplicity of construction, semiautomatic action, more uniform temperature distribution, no danger of shock, limited maximum power demand, and ability to sterilize soil of high specific resistance. It was also found from the data at what moisture content was the least energy requirement and also what was the lowest moisture content practicable for sterilization. These last two findings were utilized for designing purposes as will be shown below.

DESIGN CALCULATIONS

From the accumulated data gathered during the various experimental runs, the characteristic performance curves of the constant current transformer used were plotted as shown in fig. 3. By means of methods for curve fitting, the equations of these curves were determined, as follows:

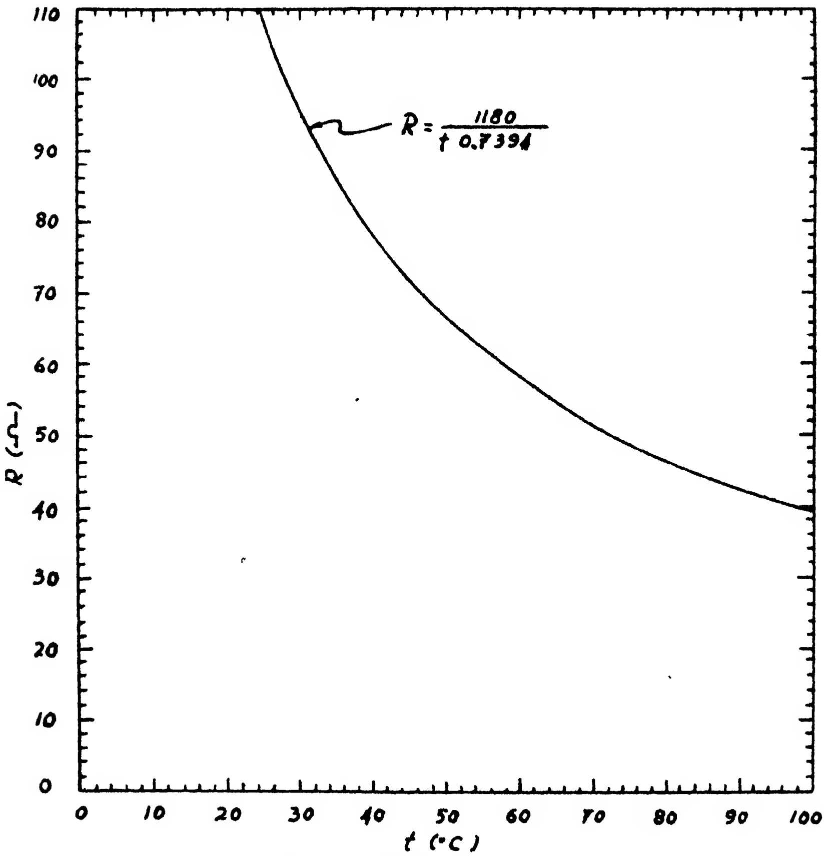

Fig. 4a. Temperature-resistance characteristic of sandy loam with 10.25 per cent moisture content.

$$\left.\begin{aligned} E &= 6.34\,R - 0.5 && \text{for } R = 16\,\Omega \text{ to } 50\,\Omega \\ E &= \frac{R}{0.00217R + 0.0434} && \text{for } R = 50\,\Omega \text{ to } 392\,\Omega \end{aligned}\right\} \quad (1)$$

$$\left.\begin{aligned} I &= 6.36 && \text{for } R = 16\,\Omega \text{ to } 50\,\Omega \\ I &= \frac{8.6874}{e^{0.01\,R}} && \text{for } R = 48\,\Omega \text{ to } 392\,\Omega \end{aligned}\right\} \quad (2)$$

$$\left.\begin{array}{l} P = 0.0403\,R - 0.00318 \text{ for } R = 16\,\Omega \text{ to } 50\,\Omega \\ P = \dfrac{1}{0.233 + 0.00455\,R} \text{ for } R = 50\,\Omega \text{ to } 392\,\Omega \end{array}\right\} \quad (3)$$

In the above equations

E = transformer secondary potential difference in volts;
I = transformer secondary current in amperes;
P = transformer secondary power output in kilowatts;
R = resistance of the soil load in ohms.

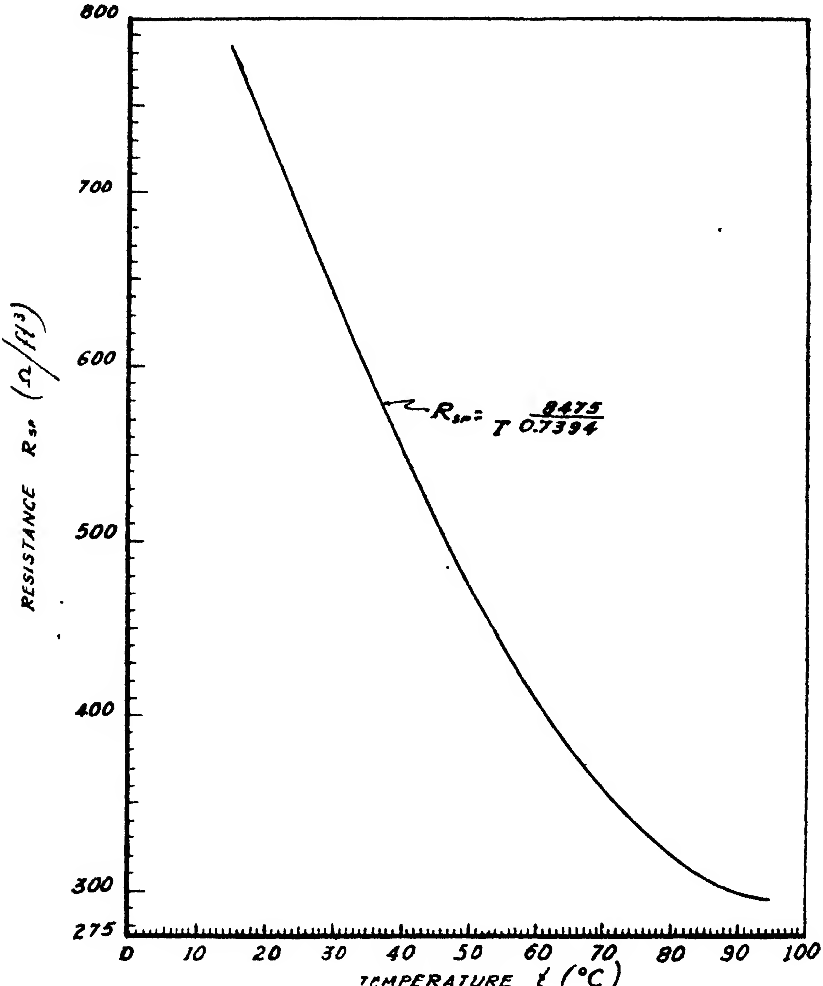

FIG. 4b

The moisture content of sandy loam soil which required the least energy consumption for sterilization was 10.25 per cent. With this moisture content the volume of soil was 1.372 cubic feet; the depth of soil, 5.25 inches; the initial temperature, 25° C.; the final temperature, 98.6° C.; actual temperature rise, 73.6° C.; time required to raise the soil temperature to final value, 70 minutes; and the time of run up to 80° C., 40 minutes. The energy consumption to final temperature was 2.3 kwh. and that to 80° C. was 1.2 kwh.

The characteristic curves obtained for sandy loam during sterilization under the conditions given above are shown in fig. 4a and in fig. 4b. The equations of these curves are as follows:

$$\left.\begin{aligned} R &= \frac{1180}{t^{0.7394}} \\ R_{sp} &= \frac{8475}{t^{\,0.7394}} \end{aligned}\right\} \quad (4)$$

In these equations

R = total resistance of the soil (sandy loam) in the sterilizer in ohms;

R_{sp} = specific resistance of the soil (sandy loam) in the sterilizer in ohms per foot.[3]

t = temperature of the soil in °C.

To be able to sterilize 5 cu. ft. (or any volume up to a certain limit) of sandy loam with the same economy of energy consumption as above and under the same conditions, it will be necessary to proportion the dimensions of the sterilizer so that the initial and final total resistance of the sandy loam soil in the sterilizer will remain the same as those in the experimental run. The calculations for the dimensions are as follows:

Let V = 5 cu. feet, volume of sandy loam to be sterilized with 10.25 per cent moisture content;

t_1 = 25° C., initial temperature of soil to be sterilized;

t_2 = 80° C., final temperature of soil to be sterilized;

A = cross-sectional area of the cylindrical sterilizer in square feet;

D = diameter of cylindrical sterilizer in feet;

R_1 = initial total resistance of the soil load in ohms;

R_{sp_1} = initial specific resistance of the soil load in ohms per ft.[3];

Δt = temperature rise in Centigrade degrees;

T = length of run in minutes

Then

$$R_1 = \frac{1180}{t^{0.7394}} = \frac{1180}{25^{0.7394}} = \frac{1180}{10.807} = 109\ \Omega$$

$$R_{sp_1} = \frac{8475}{{}_t0.7394} = \frac{8475}{0.7394} = \frac{8475}{10.807} = 784 \ \Omega \ /ft.^3$$

Now $V = A\left(\frac{H}{12}\right) = 5$

$$\therefore A = \frac{5}{\frac{H}{12}} = \frac{60}{H}$$

Also $R_1 = R_{sp_1}\dfrac{\frac{H}{12}}{A}$

$$\text{or } 109 = 784\,\frac{\frac{H}{12}}{\frac{60}{H}} = 784\left(\frac{H}{12}\right)\left(\frac{H}{60}\right) = \frac{784\ H^2}{720} = 1.09\ H^2$$

$$\therefore H^2 = \frac{109}{1.09} = 100$$

$$H = \sqrt{100} = 10 \text{ inches}$$

$$\text{and } A = \frac{60}{H} = \frac{60}{10} = 6 \text{ sq. ft.}$$

Now $A = 0.7854\ D^2$
or $6 = 0.7854\ D^2$

$$\therefore D = \sqrt{\frac{6}{0.7854}} = \sqrt{7.64} = 2.76 \text{ ft. or } 2' - 9''$$

$$\Delta t = t_2 - t_1 = 80 - 25 = 55^\circ \text{ C.}$$

$$T = 40\left(\frac{5}{1.372}\right) = 146 \text{ minutes or 2 hrs. and 26 min.;}$$

(NOTE.—In the original experiment it took 40 minutes for 1.372 cu. ft. of soil to have a temperature rise of 55°C.).

$$T = 55\left(\frac{5}{1.372}\right) = 200 \text{ minutes or 3.33 hrs. for } 73.6^\circ \text{ C. rise;}$$

(NOTE.—In the original experiment it took 55 minutes for 1.372 cu. ft. of soil to have a rise of 73.6°C.).

Check:

$$R_1 = 784\,\frac{\frac{10}{12}}{6} = \frac{7840}{72} = 108.8\ \Omega \text{ (using computed dimensions);}$$

which checks $R_1 = 109\ \Omega$ from empirical formula.

$$R_2 = \frac{1180}{0.7394_{(98.6)}} = \frac{1180}{29.7} = 39.7\ \Omega \text{ (using empirical formula)}$$

$$R_2 = \frac{8475}{0.7394_{98.6}}\ \frac{\frac{10}{12}}{6} = 285\left(\frac{10}{60}\right) = 39.6 \text{ (using computed dimensions).}$$

The next step, which is very important, although a laborious one, is to predict the characteristic performance curves of the

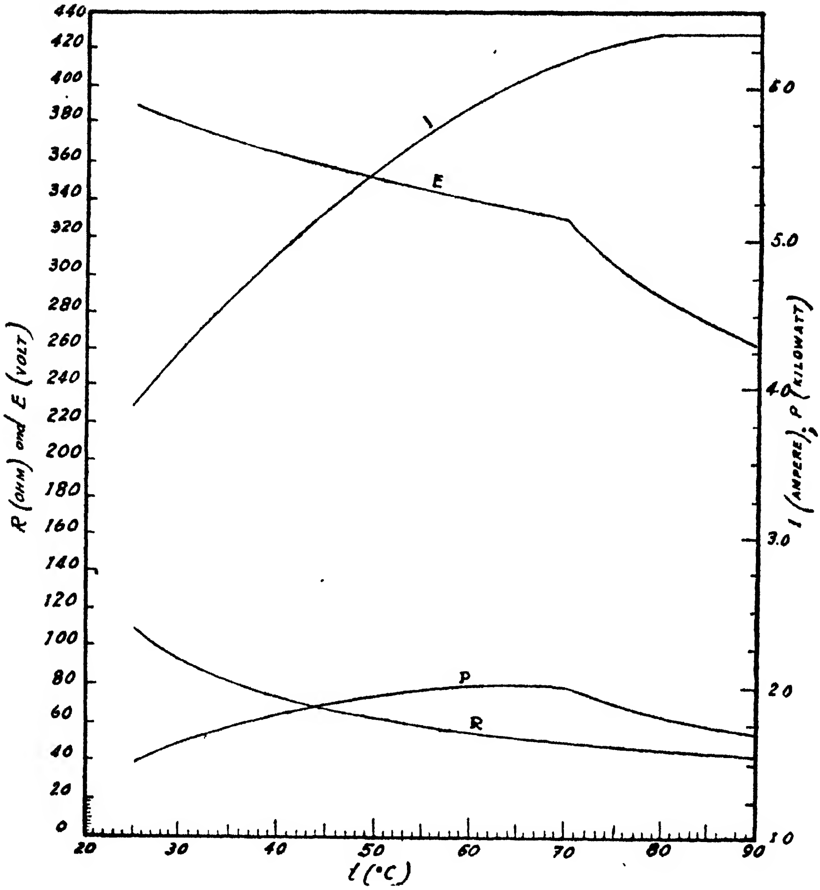

FIG. 5. Predicted performance curves for the 5-cubic foot sandy loam soil sterilizer (moisture content 10.25 per cent).

5 cu. ft. sandy loam soil sterilizer. For the group of curves, t will be plotted as abscissa and E, I, P, and R as ordinates.

Using the equation $R = \frac{1180}{t^{0.7394}}$, $E = 6.34\,R - 0.5$ for $R = 16\,\Omega$ to $50\,\Omega$, $E = \frac{R}{0.00217\,R + 0.0434}$ for $R = 50\,\Omega$ to $392\,\Omega$, $I = 6.36$ for $R = 16\,\Omega$ to $48\,\Omega$ and $I = \frac{8.69}{t^{0.01\,R}} + 0.9$ for $R = 48\,\Omega$ to $392\,\Omega$.

Table 2 can be constructed as shown below:

TABLE 2.—*Predicted performance characteristics of 5-cu. ft. sandy loam soil sterilizer (moisture content—10.25 per cent).*

t (°C.)	25	30	40	50	60	65
R (Ω)	109.0	95.5	77.2	65.4	57.2	53.8
E (volt)	390.0	381.0	366.0	353.0	341.0	336.0
I (ampere)	3.82	4.25	4.91	5.42	5.80	5.97
P = EI (watt)	1490	1620	1795	1910	1979	2009
P (kw)	1.49	1.62	1.80	1 91	1.98	2.01
T (hr.)	0	0.23	0.78	1 23	1 68	-------

t (°C.)	70	76	80	85	90	95
R (Ω)	51.0	48.1	46.2	44.1	42.3	-------
E (volt)	330.0	304.5	292.4	279.5	267	-------
I (ampere)	6.12	6.28	6.36	6.36	6.36	-------
P = EI (watt)	2020	1910	1855	1778	1707	-------
P (kw)	2.02	1.91	1.86	1.78	1.70	-------
T (hr.)	2.09	-------	2.52	-------	3 00	-------

Table 2 is shown graphically in fig. 5 and in fig. 6.

It was unfortunate that in the original experiments the weight of the soil for each run was not determined. However, from the data gathered there is sufficient information to calculate this weight very closely thus:

In the original experiment for sandy loam with 10.25 per cent moisture content V = 1.372 cubic feet, $t_1 = 25°$ C., $t_2 = 98.6°$ C., T = 55 minutes to 98.6° C., kwh. = 2.3 (input after 70 minutes) and $\Delta t = 73.6°$ C.

Let m = mass of dry soil in grams;

$\therefore$ 0.1025 m = mass of water in soil in grams;

Hence m (0.2) (73.6) + 0.1025 m (1) (73.6) = 3413 (av. kw.)

$\left(\frac{55}{60}\right)$ (252)

(Note: 3413 = B.T.U./kwh.; 252 = calories/B.T.U.)

The average kilowatt or average power demand in kilowatt can be calculated from fig. 3 as follows:

$$R_1 = 42.3\Omega;\quad R_2 = 53.0\Omega;\quad R_3 = 109.0\Omega.$$

$$\therefore \Delta R = 109 - 42.3 = 66.7\,\Omega$$

$$\text{Hence av. kw.} = \frac{1}{66.7}\left[\int_{42.3}^{53} (0.0403\,R - 0.00318)\,dR + \int_{53}^{109} \frac{dR}{0.233 + 0.00455R}\right] = \frac{1}{66.7}\left\{\left[\frac{0.0403\ R^2}{2} - 0.00318\ R\right]_{42.3}^{53} + \left[\frac{1}{0.00455}\log_e (0.233 + 0.00455\ R)\right]_{53}^{109}\right\} = 1.73$$

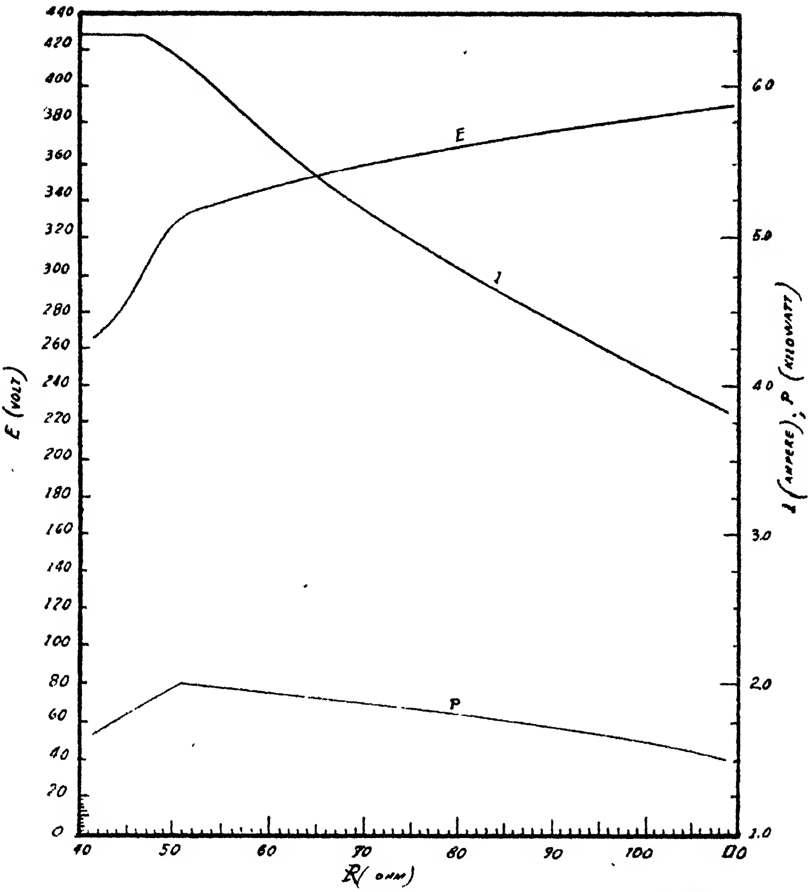

FIG. 6. Predicted performance curves for the 5-cubic-foot sandy loam soil sterilizer (moisture content 10.25 per cent).

Substituting this value in the thermodynamic equation above, we have

$$m(0.2)(73.6) + 0.1025\ m(1)(73.6) = 3413\left[(1.73)\left(\frac{55}{60}\right)\right](252)$$

$$\text{or } 14.72\ m + 7.54\ m = 1{,}380{,}000$$

$$m = 62{,}000 \text{ grams} = 62.0 \text{ kgms.}$$

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{62.0}{1.372} = 45.2 \text{ kgms./cu. ft.} = 99.3 \text{ lbs./cu. ft.}$$

$$62{,}000\ (73.6)\ (\text{av. sp. ht.}) = 1{,}380{,}000$$

$$\therefore \text{av. sp. ht.} = \frac{1{,}380{,}000}{62{,}000\ (73.6)} = 0.302 \text{ cal./gr./C}^\circ \text{ for sandy loam}$$

with 10.25% moisture content.

$$\text{kwh. output} = 1.73\left(\frac{55}{60}\right) = 1.59$$

$$\text{kwh. input} = 2.3\left(\frac{55}{70}\right) = 1.805$$

$$\text{av. eff. of transformer} = \frac{1.59}{1.805} = 0.88 \text{ or } 88 \text{ per cent}$$

Net kwh/cu. ft. $= \frac{1.59}{1.372} = 1.158$ for 73.6° C. rise or 0.787 for 55° C. rise

Gross kwh/cu ft. $= \frac{1.805}{1.372} = 1.314$ for 73.6° C. rise or 0.893 for 50° C. rise.

For the proposed 5 cu. ft. sterilizer:

m = mass of soil in grams with 10.25 per cent moisture content.
$\Delta t = 73.6°$ C.
Av. power demand = 1.73 kw.
T = time in seconds
Mass = density (volume) = 45.2 (5) = 226.0 kilograms
226,000 (0.302) (73.6) = 0.24 (1730) T
5,020,000 = 415 T
T = 12,100 secs. = 201.5 min. = 3.36 hrs.

$$\text{Input of transformer} = \frac{2.3\left(\frac{55}{70}\right)(5)}{1.372} = 6.60 \text{ kwh.}$$

Output of transformer = 1.73 (3.36) = 5.81 kwh.

$\therefore$ Ave. efficiency of transformer $= \frac{5.81}{6.60} \times 100 = 87.2$ per cent

Net kwh. per cu. ft. $= \frac{5.81}{5.00} = 1.16$ for 73.6° C. rise, or 0.798 for 50° C. rise;

Gross kwh. per cu. ft. $= \frac{6.60}{5} = 1.32$ for 73.6° C. rise, or 0.897 for 50° C. rise.

Another group of characteristic performance curves is shown in fig. 7 in which T, time in hours, is plotted against E, I, t, P, and R as ordinates. The time at which a given temperature is reached is computed as follows (fig. 7):

Let $t_1 = 25°$ C.
$t_2 = 30°$ C.
$\therefore \Delta t = 5°$ C.
$R_1 = 109\ \Omega$
$R_2 = 95.5\ \Omega$
$\therefore \Delta R = 13.5\ \Omega$

$$\text{Hence av. power demand} = \frac{1}{\Delta R}\int_{R_2}^{R_1} \frac{dR}{0.233 + 0.00455\ R}$$

$$= \frac{1}{13.5}\int_{95.5}^{109.0} \frac{dR}{0.233 + 0.00455\ R}$$

$$=\left[\frac{1}{13.5}\ \frac{1}{0.00455}\log_e(0.233+0.00455\ R)\right]_{95.5}^{109.0}=1417 \text{ watts}$$

$$\text{Then } 5{,}020{,}000\left(\frac{5}{73.6}\right)=0.24(1417)T=340\ T$$

$$T=1002 \text{ secs.}=16.70 \text{ min.}=0.28 \text{ hr.}$$

Let $t_1 = 25°$ C.; $t_2 = 98.6°$ C. $\therefore$ $\Delta t = 73.6°$ C.

$R_1 = 109\Omega$; $R_2 = 53\Omega$; $R_4 = 42.3\Omega$ $\therefore$ $\Delta R = 66.7\Omega$

$$\therefore \text{Av. power demand}=\frac{1}{\Delta R}\left[\int_{R_4}^{R_2}(0.0404\ R-0.00318)\,dR+\int_{R_2}^{R_1}\frac{dR}{0.233+0.00455\ R}\right]$$

$$=\left\{\left[\frac{1}{66.7}\ \frac{0.0403\ R^2}{2}-0.00318\ R\right]_{42.3}^{53}+\left[\frac{1}{0.00455}\log_e(0.233+0.00455\ R)\right]_{53}^{109}\right\}$$

$$=1730 \text{ watts}$$

After making the immediately preceding computations, the values of time in hours corresponding to the given temperatures are entered in Table 2 and plotted in fig. 7, as already mentioned, with the other variables as ordinates.

The same procedure is followed in designing for larger volumes up to a certain limit.

The lowest moisture content at which it was possible to sterilize sandy loam soil was 6.08 per cent. The temperature-sp. resistance curve is shown in fig. 8. With this moisture content the volume sterilized was 1.34 cubic feet; the depth, 5.13 inches; the initial temperature, 25° C.; Δ t = 49.1° C.; kwh. consumption, 1.1; and kwh./cubic feet, 0.836.

To sterilize 5 cubic feet of sandy loam under these conditions and with the same energy economy as that with 10.25 per cent

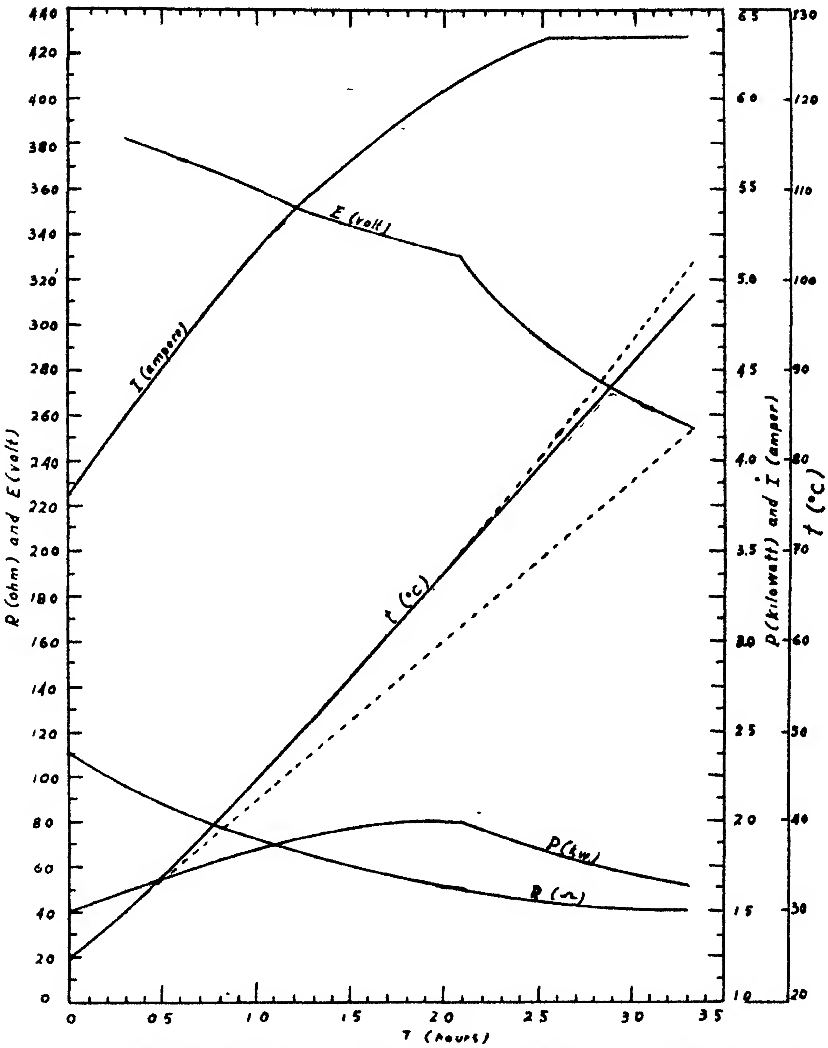

FIG. 7. Predicted characteristic performance curves of the 5-cubic-foot sandy loam soil sterilizer (moisture content 10.25 per cent).

moisture content, the dimensions of the sterilizer are computed as follows:

V = 5 cubic feet, desired volume
H = height in inches
D = diameter in feet
A = area in square feet

$$V = A\left(\frac{H}{12}\right) = 5$$

$$A = \frac{5}{\frac{H}{12}} = \frac{60}{H}$$

$$R_1 = R_{sp_1}\frac{\frac{H}{12}}{A} = \left(\frac{\frac{28{,}700}{0.812}}{25}\right)\left(\frac{\frac{H}{12}}{\frac{60}{H}}\right) = 2.93\ H^2$$

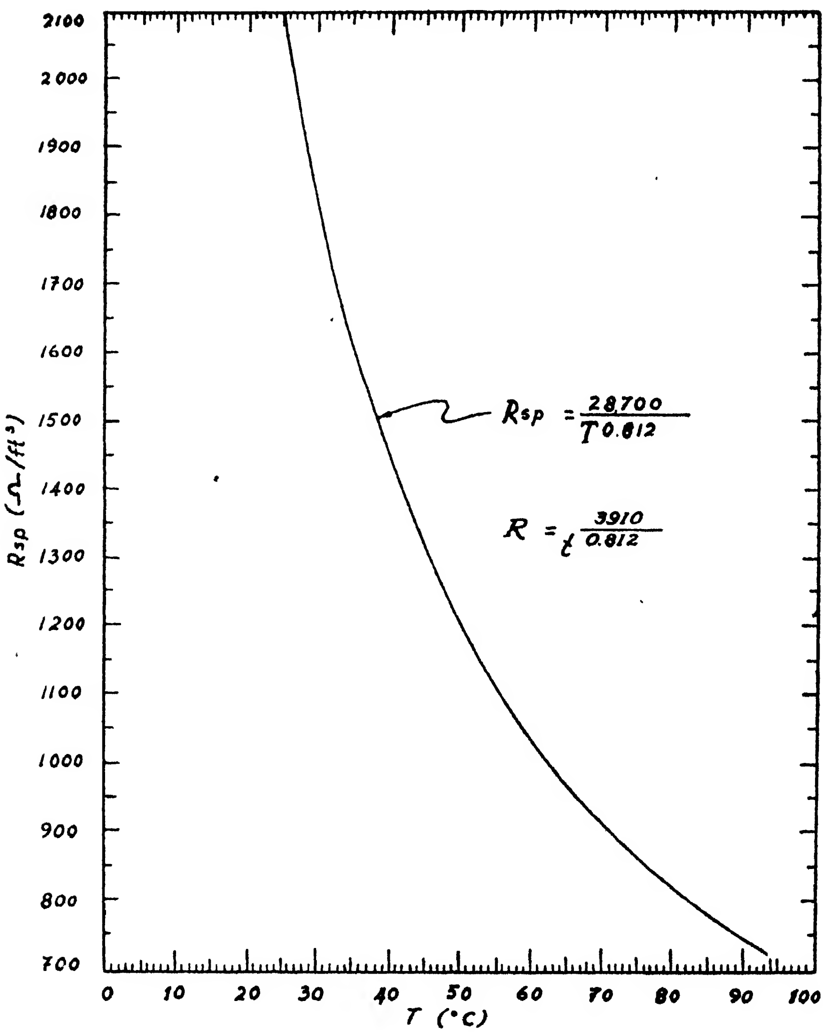

FIG. 8. Temperature-sp. resistance characteristic curves for sandy loam with 6.08 per cent moisture content.

$\therefore$ 109 = 2.93 H^2
H^2 = 37.2
H = 6.1 inches

$$A = \frac{60}{6.1} = 9.83 \text{ square feet}$$

0.7854 D^2 = 9.83
D = 3.54 feet

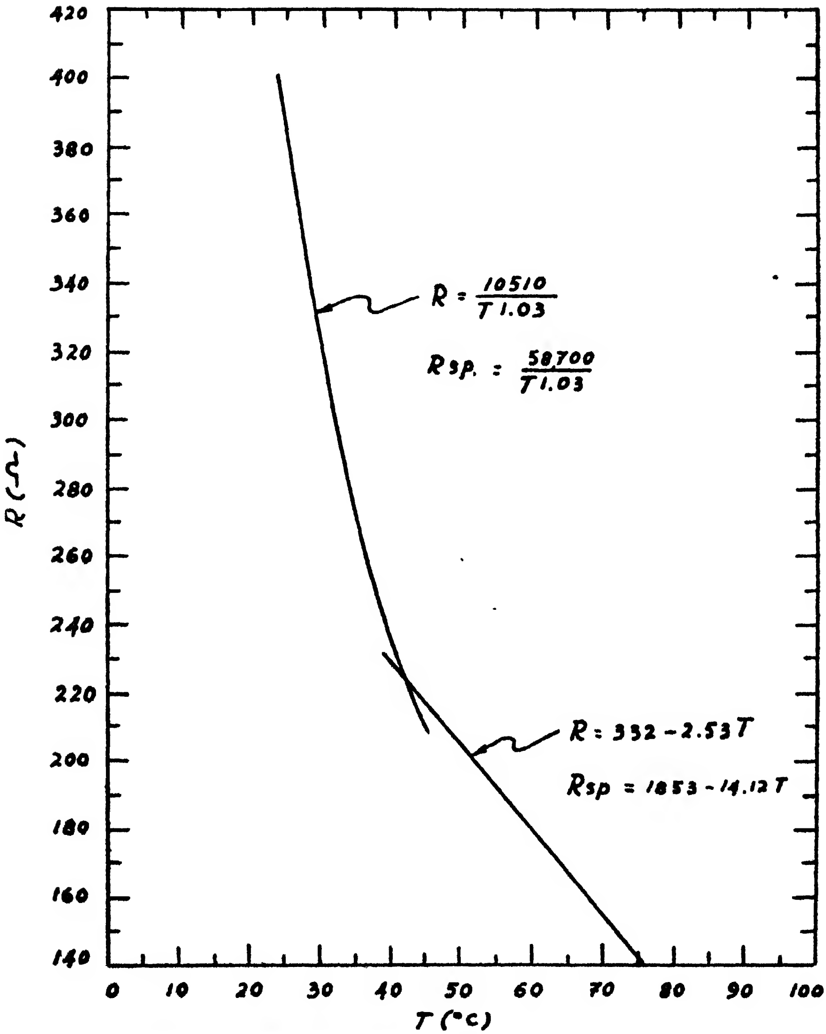

FIG. 9. Temperature-resistance characteristic of sand. Depth = 6.75 inches; V = 1.766 cubic feet; moisture content 6.45 per cent.

These dimensions make the sterilizer quite unwieldy and difficult to make rigid and therefore impractical to construct. Its characteristics need not be determined.

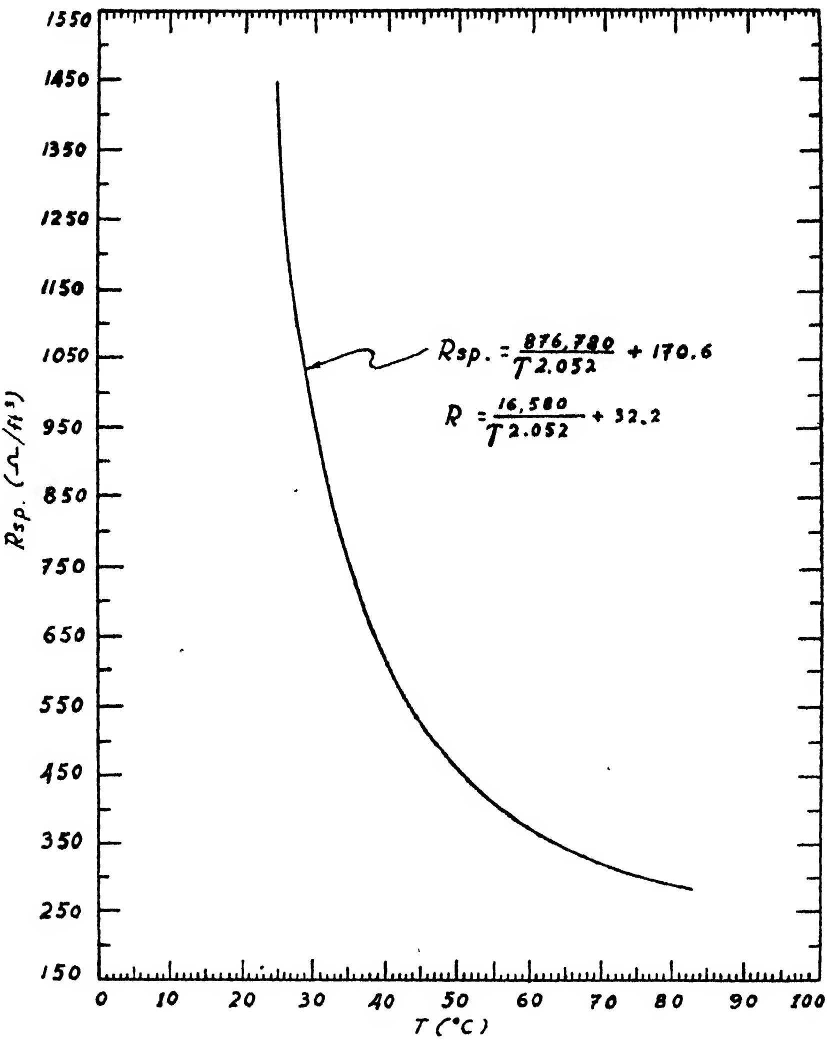

FIG. 10. Temperature-resistance characteristic of muck soil. Depth = 7.125 inches; V = 1.867 cubic feet; moisture content = 44.4 per cent.

For designing the sterilizer for sand, using the same procedure as that for sandy loam, and predicting its characteristics, the following equations and data, as obtained from the original experiments, are necessary:

$$\left.\begin{array}{l} R = \dfrac{10{,}510}{t^{1.03}} \\ R_{sp} = \dfrac{58{,}700}{t^{1.03}} \end{array}\right\} R = 225 \text{ to } R = 409\ \Omega \text{ (see fig. 9)}$$

$$\left.\begin{array}{l} R = 332 - 2.53\,t \\ R_{sp} = 1853 - 14.12t \end{array}\right\} R = 140 \text{ to } R = 225\ \Omega \text{ (see fig. 9)}$$

*Depth = 6.75 inches
Volume = 1.766 cubic feet
Moisture content = 6.45 per cent
kwh. = 1.4 from 23.8° C. to 75.7° C.
Time = 90 minutes

The equations and data for muck are as follows:

$$R_{sp} = \frac{876{,}780}{t^{2.052}} 170.6 \text{ (see fig. 10)}$$

$$R = \frac{16{,}580}{2.052} + 32.2 \text{ (see fig. 10)}$$

Depth = 7.125 inches
Volume = 1.867 cubic feet
Moisture content = 44.4 per cent
kwh. = 1.55 from 24.3° C. to 83.1° C.
Time = 80 minutes

In the case of sand and muck the moisture contents at which the energy consumptions were least, happened to be the minimum moisture contents at which sterilization was possible.

TABLE 1.—*Showing the heat required to sterilize 100 lbs. of soil at different moisture contents for a temperature rise of 90° Fahrenheit (—50° Centigrade).*

Moisture content, per cent	100	50	30	20	10	5
Total heat required, B. T. U.	10,800	6,300	4,500	3,600	2,700	2,250
Total heat required, per cent	100	100	100	100	100	100
Heat used by moisture, B. T. U.	9,000	4,500	2,700	1 800	900	450
Heat used by moisture, per cent	83 33	71.5	60 0	50 0	33 33	20 0
Heat used by soil, B. T. U.	1,800	1,800	1,800	1,800	1,800	1 800
Heat used by soil, per cent	16.37	28 5	40 0	50 0	66.67	80 0

TABLE 2.—*Predicted performance characteristics of the 5-cu. ft. electric soil sterilizer for sandy loam with 10.25 per cent moisture content.*

t (°C)	25	30	40	50	60	65
R (Ω)	109.0	95.5	77 2	65 4	57 2	53.8
E (volt)	390 0	381.0	366 0	353.0	341 0	336.0
I (ampere)	3.82	4 25	4 91	5 42	5.80	5.97
(watt—EI)	1,490	1,620	1,795	1,910	1,979	2,009
P (kw.)	1.49	1 62	1.80	1 91	1 98	2.01
T (hr.)	0	0.28	0.78	1.23	1 68	-------

TABLE 2.—*Predicted performance characteristics of the 5-cu. ft. electric soil sterilizer for sandy loam with 10.25 per cent moisture content*—Ctd.

t (°C)	70	76	80	85	90	98.6
R (Ω)	51 0	48 1	46 2	44 1	42.3	....
E (volt)	330.0	304.5	292 4	279.5	267 7	....
I (ampere)	6 12	6.28	6 36	6.36	6 36	....
(watt—EI)	2.020	1,910	1 855	1,178	1 702	....
P (kw.)	2 02	1 91	1 86	1.78	1.70	....
T (hr.)	2 09	....	2 52	....	3.00	3.36

SUMMARY

1. The voluminous data gathered in the sterilization of soil with the use of a constant-current, series lighting transformer, was condensed in the form of equations of curves which, when tested by the Chi-square test, were very highly significant and therefore fit the experimental data very closely.

The equations for the transformer are as follows:

$$\left.\begin{array}{ll} E = 6.34\ R - 0.5 & \text{for } R = 16\ \Omega \text{ to } 52\ \Omega \\ E = \dfrac{R}{0.00217R + 0.0434} & \text{for } R = 50\ \Omega \text{ to } 392\ \Omega \end{array}\right\} (1)$$

$$\left.\begin{array}{ll} I = 6.36 & \text{for } R = 16\ \Omega \text{ to } 50\ \Omega \\ I = \dfrac{8.6874}{e^{0.01\ R}} & \text{for } R = 48\ \Omega \text{ to } 392\ \Omega \end{array}\right\} (2)$$

$$\left.\begin{array}{ll} P = 0.0403\ R - 0.00318 & \text{for } R = 16\ \Omega \text{ to } 50\ \Omega \\ P = \dfrac{1}{0.233 + 0.00455\ R} & \text{for } R = 50\ \Omega \text{ to } 392\ \Omega \end{array}\right\} (3)$$

In the above equations

E = transformer secondary potential difference in volts;
I = transformer secondary current in amperes;
P = transformer secondary power output in kilowatts;
R = resistance of the soil load in ohms.

The characteristic curves for the soils are as follows:
For sandy loam with 10.25 per cent moisutre content,

$$\left.\begin{array}{l} R = \dfrac{1180}{t^{0.7394}} \\ R_{sp} = \dfrac{8475}{t^{0.7394}} \end{array}\right\} (4)$$

In these equations
For sandy loam with 6.08 per cent moisture content;

$$R_{sp} = \frac{28,700}{t^{0.812}}$$

$$R = \frac{3910}{t^{0.812}}$$

For sand with 6.45 per cent moisture water;

$$\left.\begin{array}{l} R = \dfrac{10{,}510}{{}_t1.03} \\[2ex] R_{sp} = \dfrac{58{,}700}{{}_t1.03} \end{array}\right\} R = 225 \text{ to } R = 409 \text{ (see fig. 9)}$$

$$\left.\begin{array}{l} R = 332 - 2.53 \\ R_{sp} = 1{,}853 - 14.12_t \end{array}\right\} R = 140 \text{ to } R = 225 \text{ (see fig. 9)}$$

In the above characteristic curves for different kinds of soils, the variables are defined as follows:

R = total resistance of the soil in ohms
R_{sp} = specific resistance of the soil in ohms per ft.^{3}
T = temperature of the soil in °C.

2. Using the equations above, the inside dimensions of a 5-cu. ft. resistance-type electric soil sterilizer were determined. For sandy loam with 10.25 per cent moisture content: 2′—9″ diameter × 10″ high. For sandy loam with 6.08 per cent moisture content: 3.54 feet diameter × 6.1″ high.

The same procedure of calculations can be used for designing sterilizer for sand and muck.

3. Using again the above equations, the performance curves for the sandy loam soil sterilizer were predicted and plotted. The power demand, energy consumption, and efficiency of the transformer under various conditions were calculated.

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ILLUSTRATIONS

TEXT FIGURES

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NEWSPAPER AS PROTECTIVE WRAPPER FOR JACK-FRUITS (NANGKA) AGAINST THE FRUIT FLY (BACTROCERA UMBROSA FABR.)

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SEVEN PLATES

INTRODUCTION

A fit introduction to this paper is the following quotation from the Listener, London: "Newspapers are used for other things than reading or wrapping herring. You all know that printing ink acts as a deterrent to moths, but do you act on that knowledge and wrap up your blankets and clothing in newspaper before putting them away for summer?

"Newspapers laid under a coconut matting catch the dust and dirt, which can be gathered up and destroyed rather than add to the labor of scrubbing and polishing of the floors. There are occasions when the windshield wiper of a car will not work. Wad a newspaper and rub the windshield with it. The rain will run straight off, instead of clinging to the glass. The same dry wad of newspaper will give a brilliant polish to mirrors. If you wrap a newspaper around a jug of ice-water, twisting the ends together to exclude the air, you will nnd that the water remains cool all night, with scarcely any melting of the ice. Newspapers tied into knots will keep fires going just as well as wood. And several sheets of newspapers wrapped around the body on a long cold journey will keep you quite comfortable and warm."

And now, it is a pleasure to discuss the latest use of newspapers discovered by the writer. This is to insure a good harvest of nangka fruits in the backyard or in the orchard. We all know that nangka sweetmeat is seldom exceeded as a delicacy for all occasions and nangka sherbet is a favorite among the masses. Ripe nangka eaten raw is an excellent dessert and as a source of the various beneficial vitamins.

From 1932, the year he was appointed as an instructor in the College of Agriculture at Los Baños, Laguna, to 1937, the writer observed that it was very rare for him to see nangka fruits which were unblemished. Generally a fruit is 50 per cent or more rotten and unfit for commercial purposes and only partly fit for home consumption. It is known, however, that if the fruits are covered while they are yet young, by jute sacks, wax paper, Manila paper bags or other suitable materials, they can reach maturity without being attacked by insects.

Early in September, 1937, the writer observed that from all the nangka trees growing on the campus of the College of Agriculture and in the yards of homes on Faculty Hill, there were between two to three thousand fruits, not mentioning those growing on private yards surrounding the college campus. It was a problem to bag all of them with rice sacks or wax paper or with Manila paper bags. The writer thought of bagging them with newspaper sheets.

On June 29, 1937, the writer officially requested the Dean of the College of Agriculture, Dr. B. M. Gonzalez (subsequently President of the University of the Philippines) to permit him to use all the nangka trees on the college campus for the experiment. He also requested the members of the college faculty, residing on the Faculty Hill, to let him use the nangka trees in their yards for the same purpose. It is gratifying to note that nobody refused the writer this request.

PLAN AND METHOD OF THE EXPERIMENT

The trees used in the experiment were located in the campus of the College of Agriculture (including those in the yards of the homes of faculty members on Faculty Hill) and in the U. P. High School Reservation. There were 80 trees in the former and 19 trees in the latter, making a total of 99 trees in all.

The fruits of each tree were divided into two groups; one group was bagged with newspaper and the other was not. The

numbers of fruits in each group were not equal; in fact the fruits bagged exceeded by far those not bagged. This procedure was followed for two reasons, firstly, to enable the experimenter to harvest more good fruits should the experiment prove successful and, secondly, to make possible the bagging of fruits under several conditions, such as age, degree of infection, location in the trees, and others.

Plate 1 shows clusters of female and male heads. Those marked "f" with rough skins are female and will develop to maturity, while those marked "i" are male and will not develop, but fall off in a few days. Only female heads were bagged.

Plate 2, figs. 1 to 3, shows the method of wrapping the newspaper around young nangka fruits. At first only one layer of a 4-page newspaper sheet was used for wrapping a fruit. Later two sheets were used so that the chances of exposing the fruit to attack by the fruit fly can be lessened should the newspaper be torn for some reason or another. Two-page sheets (tabloid size) were also used, but several layers were necessary and they were difficult and less neat to wrap.

Plate 3 shows the appearance of the wrapped nangka fruits on the experimental trees. An assistant and a step ladder were needed to wrap the fruits near the top of the taller trees.

The first fruits were covered on September 13, 1937 and continued up to the end of November, 1937. However, the great majority of the trees were covered during September, 1937.

RESULTS AND DISCUSSIONS

It is interesting to note, at this time, that when the experiment was begun, there were many among the writer's colleagues, who predicted that the first rain would all melt the newspaper covers, and leave the fruits exposed to the attack of the fruit flies.[1]

[1] Common name .... Nangka fruit fly
Scientific name .... *Bactrocera umbrosa* Fabr.
Family name .... Trypetidae.
Order .... Diptera.
Hosts .... Nangka, marang, breadfruit.

Damage: Jackfruit is especially attacked by this pest. It produces holes and causes rottening of the fruit.

Life history: Eggs are laid in or under the skin of the fruit, several together. Larvae are white and about 1.0 cm. long. They pupate in the soil and they fly after emergence. Life cycle takes three (3) weeks.

Control: Destroy attacked fruits by burning.

On September 14, the day after the first group of covers was put up, a slight rain occurred; then from September 18 to 23, there was continuous heavy rain. To the great satisfaction of the writer, the covers held on and were not melted and torn off as predicted. From then on, intermittent rains fell, some heavy, some slight, and the effect on the covers was unexpected. The intermittent wetting and drying made the newspapers tougher.

The covers, however, could not stand heavy rain and storms. On November 11, 1937, there was a storm and almost all of the covers were torn off from the fruits. The method of covering is so simple and the covering materials are so abundant that on November 12, 1937, all fruits were again covered anew. Again, on November 20, another typhoon occurred and the covers were all torn down once more. Not daunted by such destruction the writer and his assistant wrapped the fruits for the third and last time.

One very interesting observation was noted during the experiment. In almost all cases the bags wrapped around the fruits became nests of the common black ants. To satisfy his curiosity, the writer bagged several fruits nearing maturity and which were already attacked by the fruit flies so that several spots of the fruits were already rotten. To his amazement, when the fruits matured (a ripe nangka fruit exudes a very strong and pleasant odor) and harvested, the rotten parts were healed and became healthy. Apparently, the black ants ate the rotten portion, including probably the larvae of the fruit flies. Plate 4, fig. 1, shows such a fruit.

Records of the experiment showed the following:

No. of fruits covered	548
No. of fruits covered and harvested in good condition	548
Total weight of fruits harvested in good condition.........kilos....	3,750.2
Range of weights of harvested fruits in good condition ....do.......	3 to 17
Average weight of harvested fruits in good condition ....do.......	6.5

The flavor and the tenderness of the fruits were apparently improved according to many students who sampled them for eating. There were variations in sweetness, flavor and quality of the flesh from tree to tree. The experimental trees evidently belong to many strains, because all of them had been grown from seeds and not one was grafted or budded.

So long as the covers remained undamaged, or replaced within a day or two when damaged, the fruits matured without or with negligible blemish (Plate 4, fig. 2).

It took an average of about one minute to cover one fruit. At the beginning, of course, the time of covering one fruit was long but an experience of one day was sufficient to make the person doing the covering proficient.

More than 230 fruits which were left uncovered developed to maturity and, in almost every case, they were attacked by the fruit flies so that only in a negligible few were it possible to obtain substantial portions for eating or cooking purposes. Not a single one was of marketable quality as can be seen in Plate 5, fig. 1. No attempt was made to weigh the defective fruits.

It was also observed that if a covered fruit had the cover destroyed and it was not repaired, the fruit was invariably attacked as shown in Plate 5, fig. 2. On the other hand, if the damaged cover is repaired within a day or two, the fruit matured well.

Many fruits which were uncovered fell long before maturity, because they were probably attacked soon after they were formed. Such fruits are shown in Plate 6.

Plate 7 shows some of the big fruits, the largest weighing 17 kilograms.

SUMMARY

1. Under Los Baños conditions, observations made by the writer from 1932 to 1937 revealed that most of the nangka fruits were attacked by the fruit fly before reaching maturity, unless covered by jute sacks or other materials.

2. Permission was granted the writer by the Dean of the College of Agriculture, Laguna, to use the nangka trees in the college campus and in the yards of the homes on Faculty Hill for experimental purposes. The writer covered the fruits with newspaper bags, because this material was plentiful and the making of the bags, very simple.

3. In every case, covered fruits developed to maturity, provided that the cover when broken was replaced within a day or two.

4. In almost every case, the uncovered fruits were attacked by the fruit fly, *Bactrocera umbrosa* Fabr. Those that ripened were not marketable. Many fell down before maturity, because of the severity of the attack.

5. If the cover was broken and not replaced, the fruit was invariably attacked.

6. Infected fruits which were covered and black ants introduced inside the cover, healed and developed to maturity, because the ants devoured the rotten portions, including probably the larvae of the fruit fly.

7. The newspaper bags were not destroyed by heavy rains. On the contrary, alternate wetting and drying made the bags tougher.

8. Rain and strong wind destroyed the bags. Replacement were readily made, because of the abundance of the material and simplicity of application.

ILLUSTRATIONS

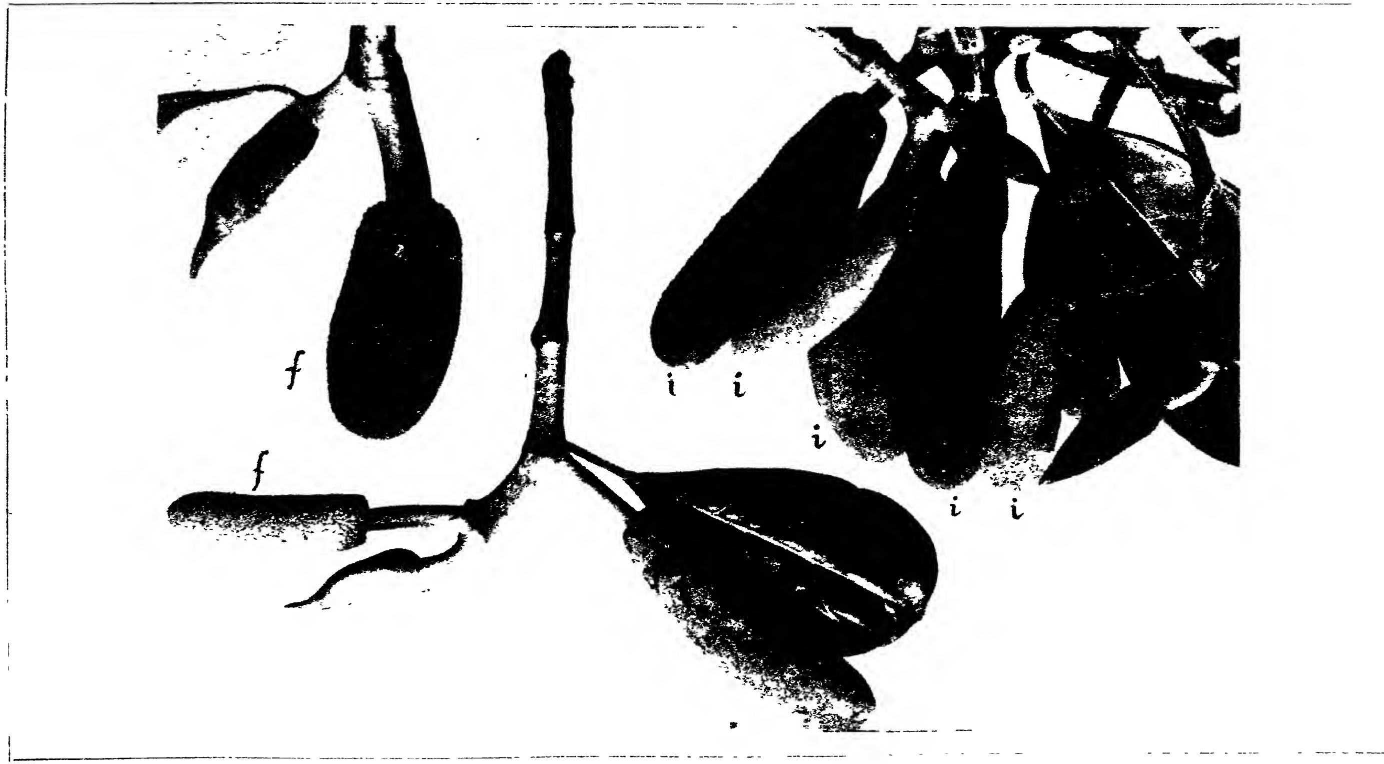
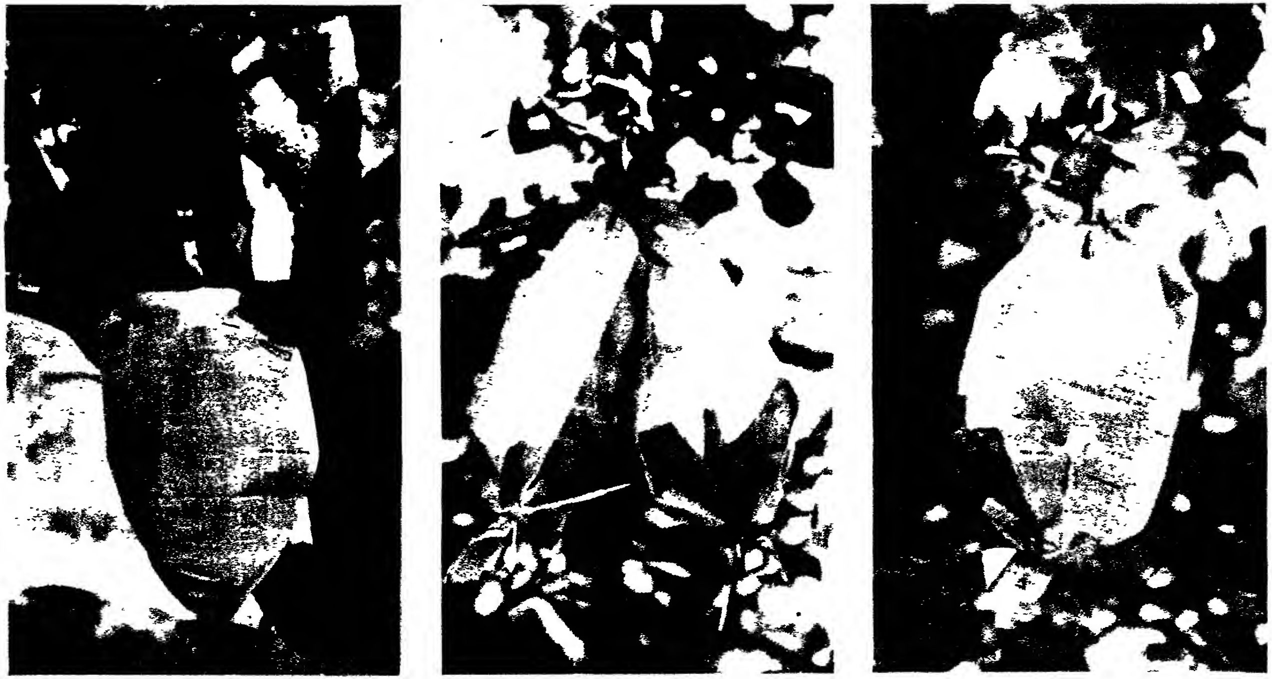


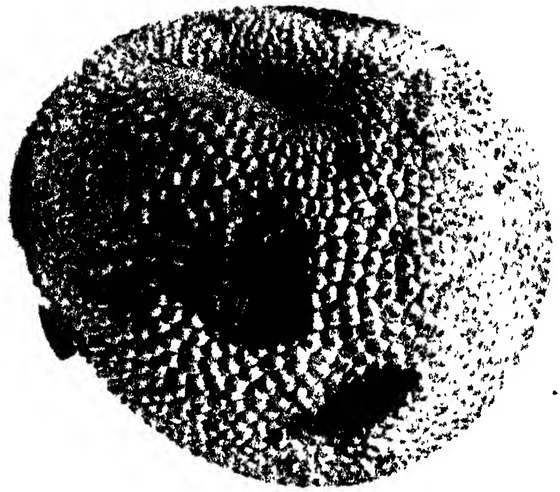
PLATE 1



1 2 3

PLATE 2

PLATE 3



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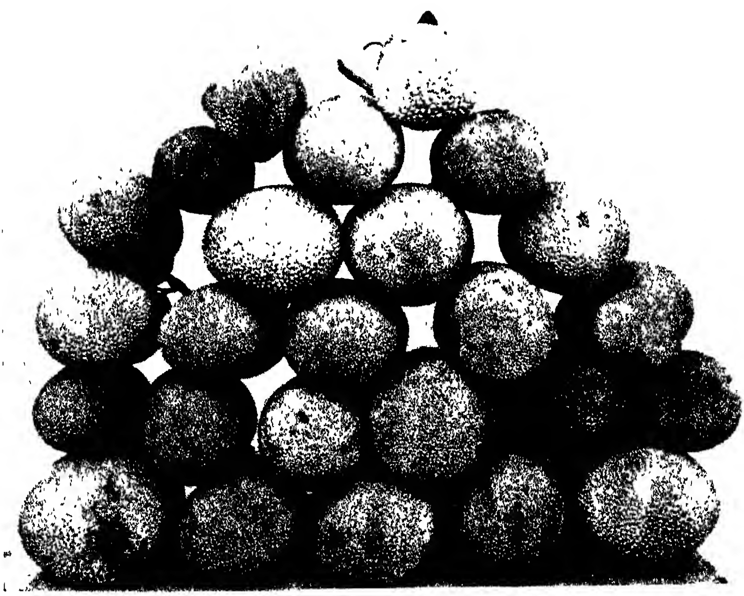

2

PLATE 4

1

2

PLATE 5

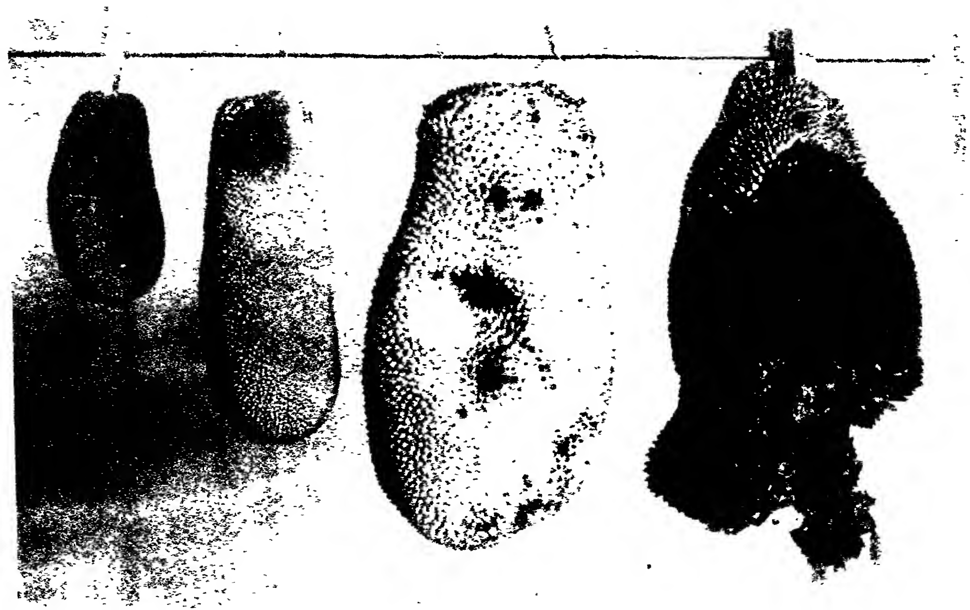

PLATE 6

PLATE 7

THE EFFECT UPON THE YIELD ON RICE VARIETY KAAWA OF THE APPLICATION OF DIFFERENT AMOUNTS OF AMMONIUM SULPHATE

By VICTORIO P. ANTONIO and JULIAN RODRIGUEZ
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SIX PLATES AND ONE TEXT FIGURE

INTRODUCTION

Importance of the study.—One of the most important problems confronting our country today is to be self sufficient in our rice needs. A possible and practical way by which we can increase our present production immediately in order to meet the exigencies of the time is to apply organic or inorganic fertilizers in our fields planted to rice, these fertilizers being available locally at reasonable prices and within the financial reach of every rice grower.

According to experiments conducted by the Bureau of Plant Industry and the College of Agriculture before the war, the application of organic fertilizers on the different varieties of lowland rice increased their yields considerably. The effect of ammonium sulphate fertilizer alone on rice Kaawa and the best rate of application have not been worked out, hence this study was conducted.

Review of literature—Butac (1933), using ammonium sulphate fertilizer with Ramai rice variety at the rates of 100, 150, 200 and 250 kilograms per hectare, found that the 100-kilogram treatment gave the highest computed yield, 89.45 ± 2.05 cavans per hectare; the 150-kilogram rate, second, with a computed yield of 86.12 ± 0.68 cavans per hectare; the 200-kilogram treatment, third, with 72.85 ± 1.53 cavans per hectare; and the 250-kilogram treatment, fourth, with 71.26 ± 1.809 cavans per hectare. The control gave an average computed yield per hectare of 70.87 ± 2.214 cavans. When the gain or loss was computed he found that the 100-kilogram treatment gave the highest gain, ₱28.66 per hectare. The 200- and 250-kilogram treatments gave loses of ₱13.04 and ₱20.47 per hectare, respectively.

Object of this study.—The object of the experiment was to find out the relative effects upon the yield of Kaawa rice of the application of different amounts of ammonium sulphate fertilizer. Kaawa is a palagad rice in Rizal, Cavite, and Laguna Provinces with the First Type of climate. In this test, it was subjected to upland condition and the intermediate A type of climate.

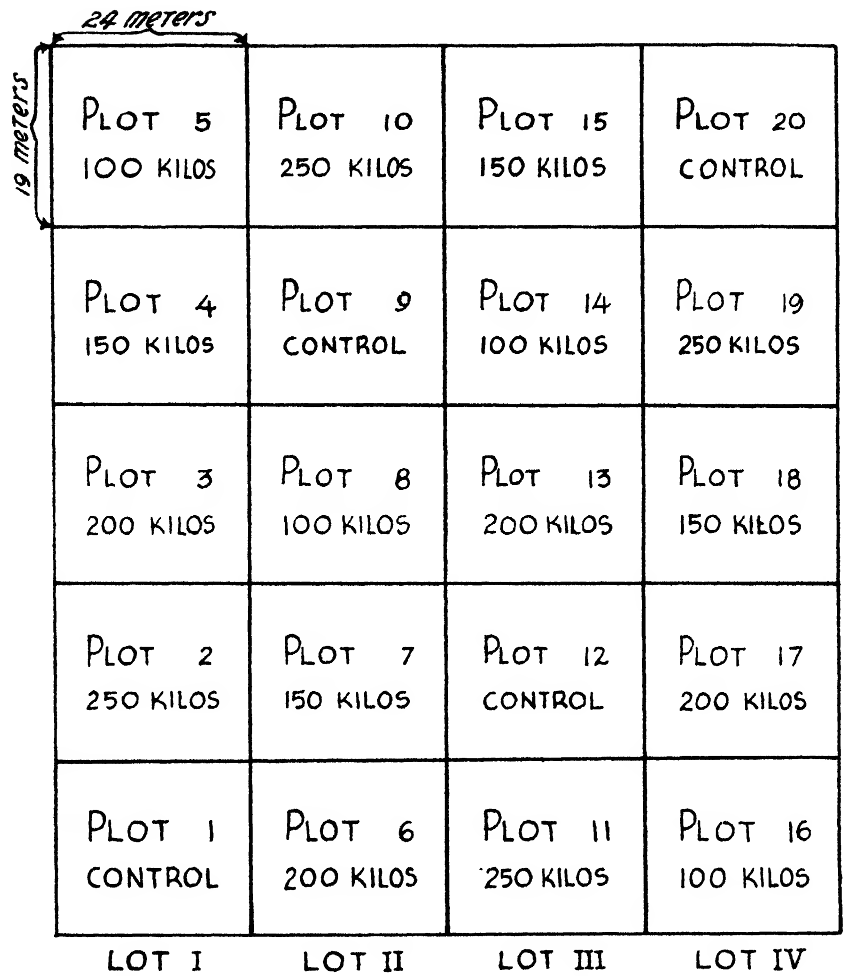
Time and place of this study.—The experiment was conducted on a level one-hectare lot at the experimental fields of the Ilagan Tobacco Experiment Station, Ilagan, Isabela, from May, 1947 to October, 1947. The soil is light clay loam and subject to inundation during high floods.

MATERIALS AND METHODS

Variety used.—For the purpose of this study, the variety Kaawa was selected because it is one of early maturing rice varieties that give a fair yield.

Field used and its preparation.—The land was plowed and harrowed three times. After the third harrowing, the land was divided into four lots, each measuring 24 by 100 meters, allowing a space of 1 meter between lots. Each lot was further subdivided into 5 equal plots each measuring 19 by 24 meters, allowing a space of one meter between plots. After the lots and plots were laid, a canal 70 centimeters wide and 50 centimeters deep was made in the one-meter space between the lots and plots. These canals were made in order to avoid any transfer of fertilizer from one plot to the other in case of rain. The area of each plot was 456 square meters.

Arrangement of plots and replication of treatments.—To minimize errors due to soil variability, the plots were randomized and numbered from 1 to 20 as can be seen in the diagram (text fig. 1). In lot 1, plot 1 served as control, and plots 2, 3, 4, and 5 received 250, 200, 150 and 100 kilograms per hectare, respectively. In lot II, plots 6, 7, 8, and 10 received 200, 150, 100 and 250 kilograms per hectare, respectively, while plot 9 served as control. In lot III, plots 11, 13, 14, and 15 received 250, 200, 100, and 150 kilograms per hectare, respectively, while plot 12 served as control. In lot IV, plots 16, 17, 18, and 19 received 100, 200, 150, and 250 kilograms per hectare, respectively, while plot 20 served as control. From the foregoing it is to be noted that each treatment and control were replicated four times.



TEXT FIG. 1. Layout of fertilizer experiment on "Kaawa" upland rice.

Planting.—As soon as the lots and plots were laid and the canals between them made, straight furrows distanced 50 centimeters apart were laid lengthwise in each lot. There were 48 rows in each lot. Planting was done immediately after the furrows were laid. The seeds were drilled in the row 4 to 5 seeds per hill. The hills were distanced about 20 to 25 centimeters apart in the row. The rate of seeding was one cavan to the hectare. In order to have a uniform rate of seeding in every plot, and using 1 cavan of seeds to the hectare as a basis, 1.14 gantas of seeds were planted in each plot with an area of 456 square meters.

Fertilizer used and method of application.—Ammonium sulphate sent by the Central Office, Manila, to this station was used for the experiment. When the rice plants were about 20 to 25 centimeters high, that is, 18 days after planting and before the final cultivation or hilling up was done, the fertilizer was applied.

In order to be sure that the correct amounts of fertilizers were applied to their corresponding plots, paper bags containing the needed measured amounts of fertilizer were correspondingly labeled from 1 to 20.

Paper bags numbered 5, 8, 14, and 16 each containing 4.56 kilos of ammonium sulphate fertilizer corresponding to the 100-kilogram treatment per hectare were distributed to plots Nos. 5, 8, 14, and 16, respectively.

Paper bags numbered 4, 7, 15, and 18 each containing 6.84 kilos of ammonium sulphate fertilizer corresponding to the 150-kilogram treatment per hectare were distributed to their corresponding plot Nos. 4, 7, 15, and 18.

Paper bags numbered 3, 6, 13, and 17 each containing 9.12 kilos of ammonium sulphate fertilizer corresponding to the 200-kilogram treatment per hectare were distributed to plots Nos. 3, 6, 13, and 17.

Paper bags numbered 2, 10, 11, and 19 each containing 11.4 kilos of ammonium sulphate of fertilizer corresponding to the 250-kilogram treatment per hectare were distributed to plots Nos. 2, 10, 11, and 19, and empty paper bags numbered 1, 9, 12, and 20 were distributed to plots Nos. 1, 9, 12, and 20 which were to serve as control plots.

The numbering of the plots in accordance with the diagram and the distribution of the numbered paper bags were checked and rechecked before the application was started. This was done so as to avoid any error due to misplacement of fertilizer.

To equalize as much as possible the distribution of fertilizer among the plants in the row and among the rows in each plot, the fertilizer in each paper bag was divided into 48 equal parts, there being 48 rows in each plot. One part of the fertilizer was distributed evenly among the plants in each row.

Since the rice seeds when planted were drilled in the row, the application of fertilizer had to be done individually in each hill. With the use of a hand trowel, a ring about 5 centimeters deep with a radius of about 5 centimeters was first made around the hill and then the fertilizer was applied

in the ring. After the fertilizer was applied, the ring was covered with fine soil and the plant was hilled up. Weeding, cultivation, and hilling up were done incidentally when the fertilizer was applied. The plots that received no fertilizer and served as control were also cultivated and hilled up on the same day.

Care of the plots.—After the fertilizer was applied the entire field was weeded from time to time weeds appeared. Final hilling up with a plow was done when the plants were about knee high or exactly 30 days after planting and 12 days after the application of the fertilizer.

Threshing and winnowing.—After harvesting, the individual plots were separately threshed, winnowed, and dried. The cleaned palay from each lot was thoroughly dried before weighing. The weights of the harvests from the individual lots were recorded.

EXPERIMENTS AND RESULTS

1. *Observations:* (*a*) *Blooming and harvesting.*—It was observed that in general the plants in the control plots headed earlier than those that were fertilized. It was also noticed that the plants that received higher rate of fertilizer headed one or two days later than those plants that received less fertilizer as can be seen in the following dates of heading:

Treatment	Days after planting
Control	67
100-kilogram treatment	68
150-kilogram treatment	69
200-kilogram treatment	70
250-kilogram treatment	71

Ninety-eight days after planting the plants in the control plots were separately harvested; 100 days after planting the plants that received the 100- and 150-kilogram treatments were harvested; 102 days after planting the plants in the 200- and 250-kilogram plots were also harvested. The Kaawa matured in 98 to 102 days. It has been observed that the application of fertilizer delayed the maturity of the rice from 2 to 4 days.

(*b*) *Relative effect on the external appearance of the plants.*—Ten days after the application of the fertilizer, the effects on the treated plants were noticeable. The leaves of the fertilized plants were green, while the leaves of the untreated plants remained pale green. Twenty days later, a more marked

effect was very visible. The plants that received the 100- and 150-kilogram treatments were green; the plants that received the 200- and 250-kilogram treatments were darker green with broad leaves while the untreated plants remained yellowish green and shorter than the treated plants.

In general it was observed that the treated plants were taller, darker green in color with broader leaves, better developed heads and panicles and had more tillers than the control. The higher the amount of fertilizer applied, the broader and darker in color were the leaves of the plants.

As the plants advanced in maturity, it was observed that the plants under the 200- and 250-kilogram treatments had the tendency to lodge. This might have been due to the fact that the plants that received the 200- and 250-kilogram treatments had more vegetative growth than the rest as can be seen in Plates 5 and 6.

(*c*) *Pests and diseases.*—There were apparently no diseases that affected the plants. As the panicles were beginning to come out and during the milk stage, the rice bug, *Leptocorisa acuta* Thunb., was found attacking the grains. The insects, however, were few and the damage done was negligible. About the same time, the maya, *Munia jagori* Martens, also began to attack the grains but they were driven away by laborers as they appeared. The damage done by the maya was also negligible.

2. *Yield of the different plots.*—Table 1 shows the actual yields and the computed yields per hectare of the different plots. Table 2 shows the average computed yield per hectare from the different treatments. Table 3 shows the significance of the difference between yields of the control and the different treatments. Table 4 shows the average yields and increase in yield due to the different treatments. Table 5 shows the gain or loss as affected by the different rates of application of fertilizer.

DISCUSSION OF RESULTS

Comparative yields obtained as a result of the application of different amounts of fertilizer.—From Table 1 it can be seen that the control gave a computed yield of from 18.14 to 38.83 cavans with an average yield of 28.03 $\pm$ 3.0767 cavans per hectare; the 100-kilogram treatment, from 25.87 to 40.02 cavans

with an average computed yield of 34.17 ± 2.0242 cavans per hectare; the 150-kilogram treatment, from 31.30 to 47.35 cavans with an average computed yield of 41.17 ± 2.3490 cavans per hectare; the 200-kilogram treatment, from 29.65 to 43.40 cavans with an average computed yield of 38.66 ± 2.0737 cavans per hectare; and the 250-kilogram treatment, from 19.14 to 39.07 cavans with an average computed yield of 30.45 ± 2.83 cavans per hectare.

TABLE 1.—*Showing the actual and computed yields per hectare of the different plots.*

Plot number	Area	Amount of fertilizer applied to each plot	Amount of fertilizer used per hectare	Yield of each plot	Computed yield per hectare
Control	*sq. m.*	*kg.*	*kg.*	*kg.*	*Cavans*
1	456	(a)	(a)	77.9	38.83
9	456	(a)	(a)	64.3	32.05
12	456	(a)	(a)	46.3	23.08
20	456	(a)	(a)	36.4	18.14
100 kg.					
5	456	4.56	100	80.3	40.02
8	456	4.56	100	76.2	37.98
14	456	4.56	100	65.4	32.60
16	456	4.56	100	51.9	25.87
150 kg.					
4	456	6.84	150	83.8	41.77
7	456	6.84	150	88.8	44.26
15	456	6.84	150	95.0	47.35
18	456	6.84	150	62.8	31.30
200 kg.					
3	456	9.12	200	83.0	41.37
6	456	9.12	200	87.1	43.40
13	456	9.12	200	80.7	40.22
17	456	9.12	200	59.5	29.65
250 kg.					
2	456	11.4	250	78.4	39.07
10	456	11.4	250	67.1	33.44
11	456	11.4	250	60.5	30.15
19	456	11.4	250	38.4	19.14

[a] None.

Table 2 shows the average computed yields per hectare from the different treatments. The highest yield of 41.17 ± 2.3490 cavans per hectare was obtained from the 150-kilogram treatment; the second highest from the 200-kilogram treatment with a computed yield of 38.66 ± 2.0737 cavans per hectare; the third highest from the 100-kilogram treatment with a computed yield of 34.12 ± 2.0242 cavans per hectare; the fourth from the 250-kilogram treatment with a computed yield of 30.45 ± 2.8300 cavans per hectare; and the lowest was the control with a computed yield of 28.03 ± 3.0767 cavans to the hectare.

TABLE 2.—*Showing the average computed yield per hectare from the different treatments.*

Treatments	Average computed yield per hectare
Kilograms per hectare	*Cavans*
100	34.12 ± 2.0242
150	41.17 ± 2.3490
200	38 66 ± 2.0737
250	30.45 ± 2.8300
Control	28.03 ± 3.0767

The difference in mean yields due to the application of different amounts of fertilizer is highly significant as can be seen in Table 3. Comparing the yields of the different treatments, the 150-kilogram per hectare treatment gave significantly higher yield than the 100, 250 and the control. However, the difference in mean yield between the 150-kilogram per hectare rate and the 200-kilogram per hectare rate is not significant.

As an effect of the fertilizer applied, the 100-kilogram treatment gave an increase of 6.09 cavans of 21.73 per cent over the control; the 150-kilogram treatment an increase of 13.14 cavans or 46.88 per cent over the control; the 200-kilogram

TABLE 3.—*Analysis of variance of yield of plots treated with different amounts of fertilizer.*

Source of variation	Df	Sum of squares	Variance	Computed F-value	
Total	19	5340.378			
Treatment	4	1936.893	484.223	10.005*	3.26 (5%) 5.41 (1%)
Replication or block	3	2822.722	940.907	19.441*	—3.49 (5%) —5.95 (1%)
Error	12	580.763	48.397		

* Highly significant.

Least significant mean diff. $= 2\sqrt{\dfrac{2(48.397)}{4}} = 9.8384$

(The L.S.M.D. being 9.8384, differences between any 2 mean yields per plot equal to or greater than 9.8384 is highly significant)

The mean yield of the different treatments are given below:

	Treatment				
	0	100	150	200	250
Mean yield per plot	56.2	68.5	82.6	77.6	61.1

treatment of 10.63 cavans or 37.92 per cent over the control; and the 250-kilogram treatment an increase of only 2.42 cavans or 8.63 per cent over the control as can be seen in Table 4.

Comparing the yields of the different treatments, with the control, the 150-kilogram treatment gave the highest increase of 13.14 cavans per hectare; the 200-kilogram treatment, second highest with 10.63 cavans per hectare; the 100-kilogram treatment, third highest with 6.09 cavans; and the 250-kilogram treatment, the least with only 2.42 cavans per hectare.

TABLE 4.—*Showing the average yields and increase in yield due to the different treatments*

Rate of application per hectare	Average yield per hectare	Increase in yield	
kg.	*Cavans*	*Cavans*	*Per cent*
100	34.12	6 09	21.73
150	41.17	13 14	46.88
200	38.66	10 63	37.92
250	30.45	2.42	8.63
Control	28.03		

Profit or loss due to the application of fertilizer.—Deducting the cost of the fertilizer and the expenses in its application, it was found, as can be seen in Table 5, that the 100-kilogram treatment gave a gain of ₱41.13; the 150-kilogram treatment a gain of ₱121.75; the 200-kilogram treatment, a gain of ₱82.88; and the 250-kilogram treatment, a loss of ₱27.25.

Of all the different treatments, the 150-kilogram gave the highest yield, the highest gain, and highly significant difference over the control as can be seen in Tables 1 to 5.

The application of fertilizer at a rate over 150 kilos per hectare has a tendency to increase the vegetative growth of

TABLE 5.—*Showing the gain or loss as affected by the different rates of application of fertilizer*

Rate of application per hectare	Average computed yield per hectare of the different treatments	Total cost of fertilizer and application [a]	Increase in yield	Value of increase per hectare [b]	Gain or loss per hectare due to fertilizer
kg.	*Cavans*	*Pesos*	*Cavans*	*Pesos*	*Pesos*
100	34.12	35.00	6.09	76.13	[c] 41.13
150	41.17	42.50	13.14	164.25	[c] 121.75
200	38.66	50.00	10.63	132.88	[c] 82.88
250	30.45	57.50	2.42	30.25	[d] 27 25
Control	28.03				

[a] Cost of fertilizer: 0.15 per kilo; cost of application per hectare: ₱20.00.
[b] Current price of palay: ₱12.50 per cavan.
[c] Gain.
[d] Loss.

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the plants and to decrease the yield. This can be seen from Tables 1 to 5 where there was a difference in yield of 2.51 cavans between the 150- and 200-kilogram treatments; a greater difference in yield of 10.72 cavans between the 150- and 250-kilogram treatments; and a difference in yield of 8.21 cavans between the 200- and 250-kilogram applications.

SUMMARY AND CONCLUSIONS

1. Four different rates of application of ammonium sulphate fertilizer on Kaawa rice were studied in the experiment.
2. With ammonium sulphate fertilizer, Kaawa palagad rice can be planted under upland condition and in a different type of climate from its origin.
3. The average computed yield per hectare from 100-, 150-, 200- and 250-kilogram treatments was higher than the control.
4. The 150-kilogram treatment gave the highest computed yield of 41.17 ± 2.3490 with a gain of ₱121.75 per hectare; the 200-kilogram, second highest with 38.66 ± 2.0737 cavans with a gain of ₱82.88 per hectare; the 100-kilogram, third highest with 34.12 ± 2.0242 cavans with a gain of ₱41.13 per hectare; and the 250-kilogram treatment, last with 30.45 ± 2.8300 with a loss of ₱27.25 per hectare.
5. Kaawa matured in from 98 to 102 days.
6. The control gave a computed yield of 28.03 ± 3.0767 cavans per hectare.
7. There was a great deal of vegetative growth at the expense of grain production in the 250-kilogram treatment.
8. Under Ilagan condition, the best rate of application of ammonium sulphate fertilizer on Kaawa rice is 150 kilograms per hectare.

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ILLUSTRATIONS

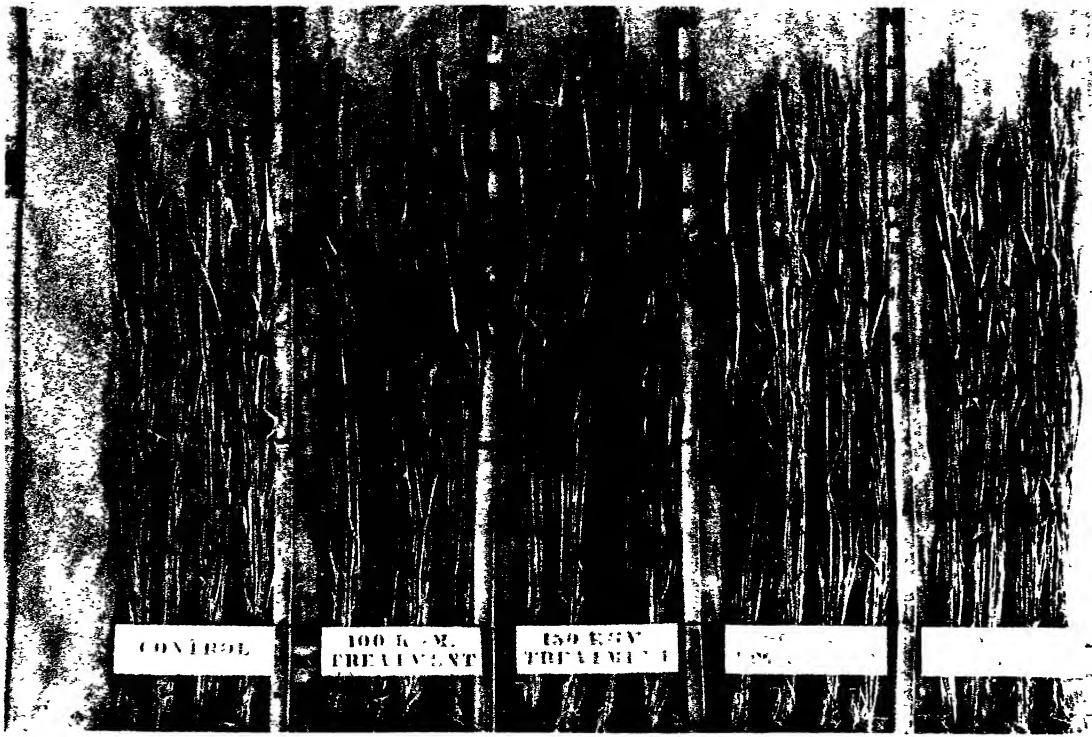

PLATE 1

PLATE 2

PLATE 3

PLATE 4

PLATE 5

PLATE 6

PRELIMINARY TESTS TO DETERMINE THE EFFICACY OF D-D AS A SOIL FUMIGANT AGAINST ROOT-KNOT NEMATODE.

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ONE PLATE AND ONE TEXT FIGURE

INTRODUCTION

D-D,[1] or Dichloropropane-Dichloropropylene, is a dark-colored liquid mixture of unsaturated chlorinated compounds. According to the pamphlets issued by the manufacturer, this new compound possesses extremely toxic properties, rendering it valuable as a soil fumigant against root-knot nematodes and other soil-borne pests such as wireworms and garden centipedes.

Although D-D is extremely toxic, it can be conveniently and safely used with the help of certain mechanical or other simpler devices. The applicator (fig. 1) is adapted for treating small fields, green house flats, and home gardens. In the absence of an applicator, the manufacturer recommends the use of simpler devices consisting of a bulb and glass syringe, or a glass funnel which might be conveniently used for treating small backyard gardens.

OBJECT OF EXPERIMENT

Obviously the main objective of the Shell Company was to determine the commercial possibilities of D-D in the Philippines. On the other hand the chief concern of the Government was to check up on the efficacy of this new fungicide for controlling root-knot nematodes under Philippine conditions.

OCCURRENCE OF ROOT KNOT

Root-knot nematode is one of the most widespread and most perplexing of plant maladies. It has been reported on egg-

[1] This new agricultural insecticide and the mechanical applicator were received by Dr. Gonzalo Merino, chief, Plant Pest and Disease Control Division, as per communication of the Shell Company of Philippine Islands, Limited, dated August 12, 1947, and subsequently turned over to the Plant Pathology Section for trial.

plant,[2] abaca[3] and tobacco[4] in the Philippines. The disease ordinarily attacks tomatoes, eggplants, lettuce, sugar beets and tobacco at the Central Experiment Station, Manila, sometime causing an uneven stand of the crops. The begonias are readily

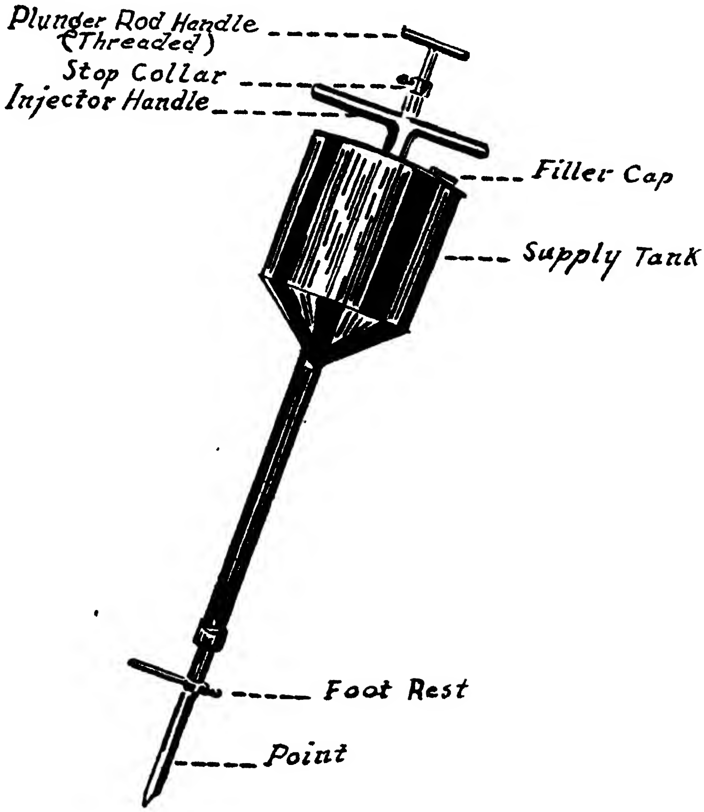

Fig. 1. A sketch of the injector

attacked by the nematode. The different varieties of begonia grown by Mr. Lorenzo Seggay from 1931 to 1941 in Los Baños Economic Garden were all badly affected by it. Seedlings of rice and sugar cane were equally susceptible to the parasite.

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[2] Palo, Macario A. Eggplant diseases and their control. Bureau of Plant Industry Farmers' Circular 44 (1936) 410–411.

[3] A handbook of Philippine Agriculture (issued in commemoration of the thirtieth Anniversary) Chapter IV. Plant Diseases pp. 245–246. Published by the College of Agriculture, U. P. (1939).

[4] Paguirigan, D. B., and Primitivo P. Tugade. Tobacco in the Philippines. Phil. Jour. Agr. 11 No. 3 (1940) 1–269; 33 plates.

Specimens of affected seedlings have been received at one time from Dr. N. B. Mendiola, senior plant breeder.

The plant malady is widely distributed in sandy soils. Accurate plant-disease surveys are not available and are not easily made. However, it may be conservatively estimated that in certain places annual crop losses caused by root-knot nematode range regularly from 5 to 20 per cent, regional losses not infrequently reaching higher levels, with instances of complete failure.

Symptoms.—The disease may be easily recognized by the enlargement or swellings on the root system of the affected plant (Plate 1, fig. 2). The swelling may vary in size from small knotty growth on finer roots to the large elongated growths on bigger roots.

Young plants that are attacked may die within a short time after infection. Older or mature plants may live longer but generally stunted, their leaves are pale green, and wilt readily under intense heat. Affected plants generally do not come to normal bearing, and in most cases affect the yield adversely.

Causal organism.—The common root-knot nematode is caused by *Heterodera marioni* (Cornu) Goodey [*Heterodera radicicola* (Greef) Müller]. The pathogene is a minute living organism commonly called nematode or eelworm. The young eelworms move about in the soil seeking the roots of the plants of their preference, and as soon as they come in contact with the tender roots they bore their way inside. The presence of these eelworms in the roots causes irritation in the tissues, resulting in the formation of root knots or swellings (Plate 1, fig. 2). These swellings contain egg-bearing female nematodes which are generally pear-shaped.[5] The eggs hatch within the root knots giving rise to several active eelworms which initiate secondary infections.

EXPERIMENTS AND RESULTS

Soil preparation and application of fungicide.—Due to the limited space available when the experiment was conducted,

[5] Cunningham, H. S., and W. F. Mai. Nematodes parasitic on Irish potato. Cornell Extension Bull. 712 (1947) 1–24; figs. 1–12.

Palo Macario A. Eggplant diseases and their control. Bureau of Plant Industry Farmers' Circular 44 (1936) 410–411.

only two plots were employed, the first having an area of approximately 15 square meters and the second a little less. As a matter of fact the space was formerly used as a dumping ground for rubbish. The plots were slightly raised to about 3 to 4 inches above the ground level.

After the plots were prepared, they were inoculated with finely chopped lettuce roots infected with root-knot nematodes. The infected materials were gathered from plots successively planted to lettuce and cabbage showing root-knot infections the previous years. The inoculum was broadcast uniformly on both plots, the soil stirred later to insure thorough mixing or incorporation. The plots were kept slightly moist for a week or more, so as to insure the success of inoculation. Two weeks after inoculation one plot was treated with D-D, leaving the other untreated to serve as control.

Calibrating the injector.—Before the fungicide was applied, the injector was first calibrated so that the proper dosage may be delivered at each injection. The calibration was made as follows: The injector's tank was first filled with D-D solution; then 10 full strokes of the plunger were made measuring the solution delivered with the use of a graduated cylinder. By dividing this by 10 the amount actually delivered by each stroke was determined. The operation may be repeated by lengthening or shortening the strokes and measuring the delivery of 10 strokes and dividing it by 10 until the desired amount of D-D per injection is obtained. In our experiments the delivery per injection was adjusted to almost 3 cc as recommended by the manufacturer. At this rate one hectare would require 49.3 gallons, costing about ₱203.95, based on the dealer's price.[6] Apparently the present cost of D-D does not come within the reach of the farmers.

Treating the soil.—The D-D was applied by means of spot injections, employing a portable injector which is already described elsewhere in this paper. These injections were made at previously marked spots on the plot, approximately 15 inches square apart.

[6] The wholesale price of 55-gallon drum is ₱217.86. Five per cent is to be added for sales tax.

Before the fungicide was applied, holes about 6 inches deep were first made at the previously marked spots with the aid of the injector's point. To do this, the foot rest was first adjusted so that it was about 6 inches above the injector's point. Then by placing one foot on the foot rest and applying pressure until the latter touched the ground, a hole at the desired depth of 6 inches was made. The injector was then lifted up and with one stroke of the plunger handle the exact amount of 3 cc of D-D was delivered into each hole. The holes receiving the nematocide were sealed with soil to allow the chemical to permeate through the plot, the temperature of which at the time of treatment was 28.5°C. This temperature, according to the pamphlets issued by the manufacturer, comes well within the range of the effectivity of the chemical, which varies from 38° to 85° F. or 3.3° to 29.4°C. The moisture of the soil when treated was just enough to permit normal working; neither too wet nor too dry.

Setting out seedlings.—The application of D-D was made on February 29, 1948, but the plots were not planted until March 1, 1948, or about a month after the treatment. The treated soil was first stirred and spread out to rid it of all toxic fumes, and after a lapse of about 12 hours, seedlings of native tomato about 5 weeks old were planted. Young seedlings were obtained from the sowing boxes of the Plant Propagation Division, and subsequently pricked in the Plant Pathology glass shed before they were used in the experiment. Only the most healthy plants whose root system showed no signs of injury or root-knot infection were transplanted in the experimental plots.

Close observations of the growth of the plants and of the presence of root-knot nematode were made throughout the experiments. It was observed that some plants in the treated plot began to wilt a few weeks after transplanting. A few days later, wilted plants also appeared in the untreated plots. All cases of wilt that were collected and examined showed no root knots. Then in a month or so later, contrasts in the growth of the plants particularly in the untreated plot became apparent, several were somewhat stunted and their leaves became lighter green or yellowish in contrast to the other plants. The plants in both plots were dug up at intervals of a few days and

examined individually for the presence of root-knot nematode. The results of examinations are given in Tables 1 and 2.

TABLE 1.—*Showing the development of root knot on tomatoes and the presence of other diseases in the treated and untreated plots.*

Date of observation.	Treated plot			Untreated plot			
	Number of plants with root knot.[a]	Number of plants without root knot.	Number of plants attacked by bacterial wilt.[d]	Number of plants with root knot.	Number of plants without root knot.	Number of plants attacked by bacterial wilt.[d]	Remarks
3-29-48			5			2	Bacterial cases were all free from root knot.
4-10-48			4			3	
4-26-48			3			2	
4-29-48			4			4	
5-3-48			6			3	
5-6-48			2				
5-19-48	[a] 2	27		20	6		
5-24-48		2		[b] 3	1		
5-27-48				4	1		
6-8-48	2	40		16	2		
6-15-48	1	26		9			
6-22-48		9		[c] 8			
Total	5	104	24	60	10	14	
Per cent	3.75	78.2	18.04	71.42	11.9	16.66	

[a] With few small swellings on the finer roots.
[b] Tops infested severely by mites.
[c] Two plants affected with *Rhizoctonia*.
[d] Those affected with bacterial wilt were free from root knot.

TABLE 2.—*Effect of D-D on the development of root-knot nematodes on tomatoes.*

Plots	No. of plants affected with root knot		No. of plants not affected with root knot		Total
	Observed	Calculated	Observed	Calculated	
Treated	5	39.84	128	93 16	133
Untreated	60	25 16	24	58.84	84
Total	65		152		217

$$\frac{(5-39.84)^2}{39.84} = 30.47$$

$$\frac{(128-93.16)^2}{93.16} = 13.03$$

$$\frac{(60-25.16)^2}{25.16} = 48.24$$

$$\frac{(24-58.84)^2}{58.84} = 20.63$$

$X^2 = 112.37$ — highly significant.

In Tables 1 and 2 above, it was shown that 104 out of 133 plants in the treated plot did not develop root-knot nematode. This represents 78.2 per cent of the total number of plants used in the experiment. On the other hand, the percentage of freedom from root knot in the untreated plot was 11.9. It was

also shown in the same table that while the untreated plot gave 71.42 per cent root-knot infection, the percentage in the treated plot was only 3.75. The results of the experiment when analyzed statistically were found to be highly significant (Table 2), that is, the difference in the number of plants attacked by nematodes in the treated and untreated plots is highly significant in favor of the treated. Evidently, the application of D-D is lethal to nematodes.

It was rather striking that in both treated and untreated plots bacterial wilt was quite rampant. For instance the bacterial wilt cases in the former reached as high as 18.04 per cent; those in the latter, 16.66 per cent. Perhaps the unusual occurrence of the bacterial wilt was favored by the excessive amount of organic matter in the soil or to some extent by the toxic effect of the nematocide. This of course requires further trials.

In order to get an approximate estimate of the yield in each plot, the marketable fruits periodically gathered are shown in Table 3. The number of infected plants successively removed and diagnosed and that left in the plot for subsequent studies are given in this table. It also gives the yield taken at a certain date corresponding to the actual number of living plants in the plot on that date.

TABLE 3.—*Showing the number of tomato plants examined and the marketable fruits harvested at different dates throughout the experiment.*

Date of examination of individual plants and date of harvest.	Treated plot			Untreated plot		
	Number of plants removed and examined.	Number of plants left.	Weight of marketable fruits.	Number of plants removed and examined.	Number of plants left.	Weight of marketable fruits
			kg.			*kg*
3-29-48	5	128				
4-10-48	4	124		2	82	
4-26-48	3	121	0.455	3	79	0.292
4-29-48	4	117	0.415	2	77	0.267
5-3-48	6	111	1.300	4	73	0.822
5-6-48	2	109	1.150	3	70	0.850
5-8-48			0.890			0.760
5-10-48			1.290			0.790
5-14-48			0.950			0.580
5-19-48	29	80		26	44	
5-24-48	2	78		4	40	
5-27-48				5	35	
6-8-48	42	36	0.620	18	17	0.260
6-15-48	27	9		9	8	
6-22-48	9			8		
Total	133		7.070	84		4.621

The total yield in the treated plot was 7.07 kilograms and that in the untreated plot was 4.621 kilograms.

SUMMARY

1. The present paper is a report of the preliminary tests on the efficacy of D-D as a soil fumigant against root-knot nematode.

2. In the treated plot, 78.2 per cent of the plants showed no root-knot nematode and only 3.75 per cent developed few small root knots which had little effect on the growth and yield of the plants.

3. In the untreated plot, while 71.42 per cent of the plants were attacked by nematodes only 11.9 per cent were not attacked.

4. The difference in the number of plants attacked by nematodes in the treated and untreated plots was highly significant in favor of the treated. Evidently D-D is lethal to nematodes.

ILLUSTRATIONS

1

2

PLATE 1

OBSERVATIONS ON THE RESISTANCE TO FLOOD OF SOME VARIETIES OF RICE

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Very often our rice crops are affected considerably by the occurrence of floods like that which swept over Central Luzon on August 24–29, 1948. With the absence of flood control systems the rice industry will infinitely suffer devastations from floods. However, it is probable that their ravages may be minimized if a commercial variety that can withstand flooded conditions could be found or developed and planted in rice fields that are exposed to the hazards of floods. Kra-suey seems to be a good material, but one of its drawbacks is that it is not a commercial variety because of its low yield. Besides it is adapted only under deep standing water but not in ordinary rice fields that are flooded only when extremely heavy rains occur.

This paper is a report on observations on the reaction to floods of some commercial varieties of rice.

Varieties and field condition.—Five lowland varieties—Ramai, Raminad Str. 3, Seraup Kechil 36, Wagwag, and Elon-elon—which were planted for comparative study on their agronomic merits were the subject of these observations. Forty-two-day-old seedlings of these varieties were transplanted singly on July 30, 1948 in the lowland rice field of the Pangasinan Provincial Nursery, Sta. Barbara, Pangasinan. The different varieties were planted side by side in rows about 3.5 meters long. Each variety occupied from 6 to 8 rows and at least 18 plants were planted in the row and spaced about 20 centimeters apart. The different varieties were about 60 centimeters apart from one another.

The plot planted to the different varieties was located on a low place, about 45 meters from the bank of Calarian Creek. The plot was observed to be flooded every time there was heavy rain and the Calarian Creek overflowed its banks. It had poor drainage and water remained standing in it until about the dough stage of the plants.

Occurrence of the floods.—Three successive floods were observed at the Pangasinan Provincial Nursery during the 1948 rice season. The first was on August 23, 24, and 25, 1948 when the total rainfall recorded at the station for each day was 6.31, 8.7, and 2.91 inches, respectively. The plants which were only 22 days old after transplanting were completely under water for almost six days. On September 1 and 2, 1948 the total rainfall for two days reached 3.51 inches and the plants were again under water. The third flood occurred on September 25, when the total rainfall recorded at the station for two days was 5.18 inches.

Observation on the resistance of the varieties to floods.—Table 1 shows the percentage of mortality due to floods in each of the varieties studied.

TABLE 1.—*Number of plants that reached maturity and percentage of mortality in the different varieties.*

Varieties	Number of rows	Total number of plants	Number of plants at maturity	Percentage of mortality
Ramai	8	144	76	47.22
Raminad Str. 3	8	144	30	79.16
Seraup Kechil 36	6	108	65	39.81
Wagwag	6	108	17	84.25
Elon-elon	6	108	42	61 11

It may be seen from the table that the different varieties differed considerably in percentage of mortality due to floods. As high as 84.25 and 79.16 per cent mortality were observed in Wagwag and Raminad Str. 3, respectively. On the other hand, Seraup Kechil 36 which was planted between Raminad Str. 3 and Wagwag had only 39.81 per cent mortality. Elon-elon and Ramai which were planted side by side with two varieties that were badly affected by the floods had 61.11 and 47.22 per cent mortality, respectively.

From the foregoing observations, it might be pointed out that ordinary lowland varieties seem to react differently under flooded conditions. The table also shows that of the five varieties, Seraup Kechil 36 seems to be the most resistant to flood as shown by the fact that it had the least percentage of mortality. On the other hand, Wagwag had the highest percentage of mortality which seems to indicate that it was the least resistant to floods among the varieties studied.

Effect of the floods on tillering and yield.—In Table 2 are presented the data on tillering, average yield per plant in grams, and the age at harvesting the different varieties.

TABLE 2.—*Tillering and yield per plant and days to maturity.*

Varieties	Average number of tillers	Average yield per plant	Days from planting to harvesting
		grams	
Ramai	10.96	34.84	210
Raminad Str. 3	24.53	50.35	210
Seraup Kechil 36	13.27	31.44	210
Wagwag	33.94	([a])	217
Elon-elon	11.07	31.76	210

[a] The greater portion of the grains was destroyed by *mayas* so that accurate yield per plant could not be indicated.

Examination of the table shows that Wagwag and Raminad Str. 3, which had very high percentage of mortality as presented in Table 1, gave high average number of tillers, 33.94 and 24.53 per plant, respectively. On the other hand, Ramai, Seraup Kechil 36, and Elon-elon, which were less affected by the floods had only 10.96, 13.27, and 11.07 tillers per plant, respectively. The high average number of tillers per plant in Wagwag and Raminad Str. 3 may be explained by the fact that because of high mortality due to floods the surviving plants had greater or wider space for development than those varieties with less mortality.

Accordingly because of the greater production of tillers in Raminad Str. 3, greater yield per plant was also obtained. An accurate average yield per plant of Wagwag could not be presented because "mayas" had destroyed or eaten up a great portion of the grains after it had been left alone in the field because of long maturity.

It may be noticed further in Table 2 that due to floods the varieties seem to have long period of maturity. Ordinarily, Ramai, Elon-elon, Raminad Str. 3, and Seraup Kechil 36 mature in less than 200 days. The delay in the period of maturity of the different varieties may have been due to the retardation of their development as a result of successive occurrence of floods during their vegetative stage.

Summary.—Observations on the reaction of some ordinary lowland varieties of rice to floods was made during the 1948 rice season when three successive floods swept over the rice field of the Pangasinan Provincial Nursery. The five varieties differed in their reaction to floods in that Wagwag seems to be the least resistant as it had the highest percentage of mortality. On the other hand Seraup Kechil 36 seems to be the most resistant with Ramai ranking next among the five varieties.

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SPLICE GRAFTING OF MANGO

By JUAN P. TORRES
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ONE TEXT FIGURE

Wester,[1] in his Bulletin No. 18, described in detail shield budding and considered it as the simplest, easiest, and most satisfactory method of vegetative propagation for mango. He suggested the setting out in the orchard at the beginning of the wet season of stocks reared in bamboo tubes for ten months and then topworking them in situ in the following dry season. In this method, according to him, there is no need to consider the state of growth of either the stock or the scion at the time of budding. However, it was stated that this method is not as applicable to the stocks growing in the nursery rows as it is to those over 18 months old or more in the orchard, because the stocks while in the nursery are in general too small in size for shield budding.

Aside from ordinary precautions usually taken in all budding work, the same author states that the only conditions are "that the scion should be well matured, green and smooth, the leaf scars well healed, and the buds inserted in the stock at a point also green and smooth like the scion." In this connection, Wester has postulated that rough and brown scions can probably be used if inserted in the stock at a point where the bark is of similar character, and if such is feasible then the stock would be budded at an earlier age and closer to the ground than if green scion is employed.[2]

Cleft grafting is just briefly described in the afore-mentioned bulletin in which Wester states in passing that sufficiently encouraging results had been attained during the past years to justify the belief that it would be practical enough for general use.

The writer of the present report, with the help of Mr. Severo Capistrano, then superintendent of Singalong Propagation

[1] Wester, P. J. The Mango. Bur. of Agr. Bull. No. 18 (1920) 1–66.

[2] Wester, P. J. Plant propagation and fruit culture in the tropics. Bur. of Agr. Bull. No. 32 (1920) 1–134.

Station, Manila, had greatly improved the local method of cleft grafting of mango, and since 1920 the use of a cylinder of Manila paper with a handful of moist sphagnum moss to cover the newly grafted scion has been employed. Since then, cleft grafting has been employed extensively in different government stations and nurseries. In fact thousands of mango stocks grown in 5-gallon petroleum cans had been successfully cleft grafted in the Central Experiment Station, Manila, from 1936 to 1941 under the former Director of Plant Industry, Mr. Hilarion S. Silayan, who foresaw and encouraged in a large measure the commercial production of grafted Carabao mango. The same method was used to some extent in the propagation of other fruit trees, like lanzon, mabolo, chico, pummelo, serali, avocado, and caimito.

Recently, the cleft grafting of mango has been briefly and clearly described by Santiago[3] including the application of fresh banana petiole in covering newly grafted scions, as a more economical substitute for Manila paper cylinder with moist sphagnum moss. It may be recalled that the use of banana petiole covering was first demonstrated in or about 1930 by one Mr. Saldana, then in charge of the Tabonoc Nursery, Tabonoc, Cebu. Its application came into general use especially in places where the banana petioles are available and at times when there is scarcity of either local or imported sphagnum moss.

The latest method in the art of propagation which the writer strongly recommends for mango is the splice grafting which was first demonstrated on avocado in September, 1947 by Mr. Agapito N. Benemerito, assistant agronomist of the Bureau of Plant Industry, at Lipa Citrus Experiment Station, Lipa City. This method was studied carefully with mango and other fruits and the results of observation are briefly discussed in this article.

Splice grafting was briefly described by Kains and McQuesten[4] in their book, *Propagation of Plants*. They claimed that this method which is done by making an oblique cut across both stock and scion of approximately equal diameter is the easiest. According to these authors it is most useful in propagating only small tender shoots which cannot be safely split.

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[3] Santiago, Jose K. Propagation of mango by cleft grafting. Plant Industry Digest 12 (1947) 16–17.

[4] Kains, M. G., and L. M. McQuesten. Propagation of Plants. Orange Judd Pub. Co., Inc., New York (1938) 555.

Selection of stocks.—The 3-month to over a-year-old stocks may be splice grafted successfully provided they are vigorous and in the prime stage of active growth as manifested by the production of new flush of leaves. With respect to the age and size of the stocks the splice grafting could be performed much earlier when they are yet too small for cleft grafting and indeed far too young for shield budding as the latter has been described by Wester. Vigorous stocks reared even in small container like 1-gallon can were splice grafted easily. In relation to the scion the stocks should be as large as the scions to be grafted or a bit larger but never smaller.

Selection and preparation of scions.—The scions or budwoods may be obtained from the first, second, or third flush of the season provided the leaves of the last flush have turned green and leathery. While the leaves are still young and tender or even when they have fully expanded but still light green, the scions that can be obtained are immature, tending to shrivel, and then die before a healthy union with the stock is effected. In preparing the scions, the leaves are first cut off at the petioles, not plucked. The scions should be from 10 to 12 centimeters in length. After a week the petiole stubs drop off from the budwoods so that in 3 weeks or so, after the removal of the leaves, and the leaf scars are well healed, with swollen buds, the scions become matured for grafting, and therefore, may be cut from the parent trees and grafted immediately (fig. 1, *a*). The defoliated bud woods should not be allowed to stay too long on the tree as within a month or so the rapid growth of buds would have taken place, rendering the scions unsuitable for grafting.

The scions to be stored in a couple of days may be wrapped carefully in 2 to 3 layers of moistened (not wet) clean typewriting paper or newspaper or gunny sack. Sawdust and sphagnum moss are the better materials for this purpose. The prepared scions should not be allowed too long in storage where it is likely to dry out, for the slightest sign of wilting of the mango budwoods, as with an almost imperceptible sign of rotting, would indicate outright spoilage of the scions. And so, the budwoods that are intended for long transit, say for several days or a week before using, should be carefully and tightly packed in sterilized materials such as sawdust or sphagnum moss and covered with oil paper before they are finally

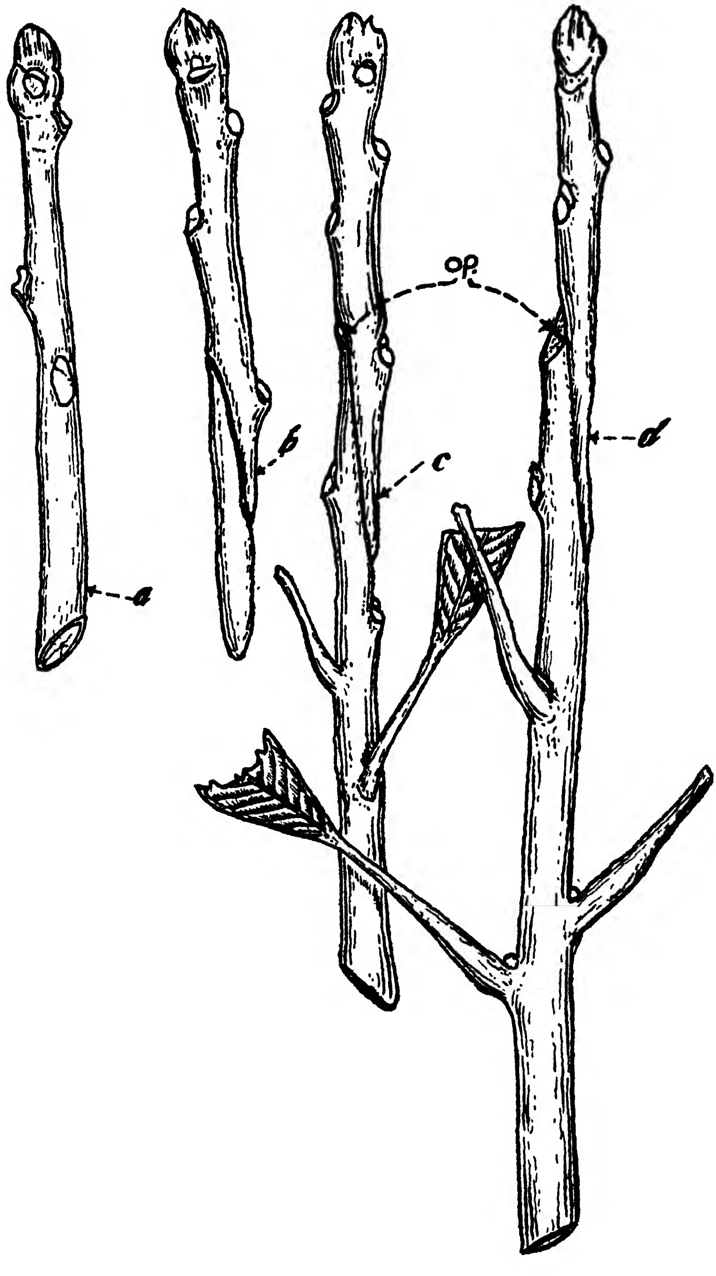

FIG. 1. Showing splice grafting of mango. *a*, Budwood; *b*, prepared scion; *c*, *d*, scion and stock brought together.

wraped up with Manila paper or they are placed tightly in cardboard tubes for shipment or mailing.

The art of splice grafting.—With a keen sharp pruning or budding knife, cut the stock seedlings at the desired height leaving intact several green leaves below the cut on the stem. When the scion and the stem of the stock are of the same size proceed to make an oblique cut on the lower end of the scion, 4 to 5 centimeters in length (fig. 1, *b*), and then make on the uppermost end of the stock a similar but a little shorter cut. At this juncture it must be noted that the entire length of the scion is about 8 to 10 centimeters. Then join the stock and scion pressing the two cut surfaces facing each other and closely fitting them together so that the cambium layer in the cut surface of the stock comes in direct contact with the cambium layer of the scion, leaving open a short upper portion of the cut on the scion to facilitate healing (fig. 1, *c* and *d*).

If the stock is a bit larger it must first be cut at an angle of 45 degrees and then make the upward cut on the backside of the stock for the implacement of the scion. As before, this upward cut on the stock should be a bit shorter than, but as wide and as deep as, the oblique cut on the scion. They are then joined together as in fig. 1, *d*, with a small opening at the upper portion of the cut surface of the scion, for obvious reason.

The scion and the stock should be bound together with a piece of budding tape, wound fairly tightly upward from a little below the lower end of the contact, completely and fitly covering all the cut portions of the stock and scion. A piece of green, fresh (not mature and yellow) banana petiole is superimposed over the scion to the full length of the wrapped stem of the stock. The hole in the banana petiole covering just fits the size or diameter of the scion to be covered and about 3 centimeters deeper than the entire length of the grafted scion. The desired depth of the hole in the banana petiole may be made by pushing into it a prepared round piece of clean wood or bamboo stick with flat or blunt end.

As in the case of budding or cleft grafting, splice grafting should be performed during the dry season if a greater success is desired. If it is to be done in the wet season or in places where there is a uniform distribution of rainfalls throughout the year, grafting should be done on bright and sunny days.

Care of grafts.—Before they become dry, the banana petiole covers should be replaced with fresh ones after the lapse of 8 to 12 days during the warm sunny days or longer during the rainy days or cool months of the year. Observation showed that in 7 to 8 days the grafted scions appear still green and sound when a healthy union between the stocks and scions is taking place but the scions turned brownish or almost black if they failed to unite with the stocks. With vigorous stocks and properly prepared scions and a healthy union taking place, the young buds on the scions may begin to appear in 2 to 3 weeks after grafting, that is while the grafted scions are still under covers. The covers therefore should not be removed prematurely as these young sprouts are likely to wither and the scions to die subsequently. The grafted scions should remain in the covers for not less than 3 weeks or 21 days.

In about 2 months after grafting the tape should be cut loose or removed entirely so as to avoid girdling and strangling or the formation of constrictions on the stems, as the stems of the grafted plants may then show signs of swelling above and below the binding tape. There were cases of deep constrictions on the stems, due to allowing the tape uncut, which resulted in the toppling or bending down of the tops at the point of the union.

Necessarily, all the sprouts below the union should be removed as fast as they appear, and the grafted plants should be allowed to develop well in the nursery before they are dug up or balled for transplanting. They should be allowed to produce 2 or 3 flushes of leaves. As soon as the last foliage formation has turned green, well matured and leathery, the grafted plants can be balled up for transplanting. It is generally known that with grafted mango care should be exercised not to break the ball and dislodge the fibrous roots while digging them from the nursery and during transplanting as the mango suffers easily from severe shock with consequent death.

Splice grafting in top working.—The splice grafting has been successfully employed by the writer in topworking mango, serali, tiessa, citrus, and chico. Unproductive trees that failed to take crown-grafted scions usually bear abundant sprouts near the cut, and some of these new shoots were selected and splice grafted successfully. According to Mr. Benemerito splice grafting is generally used in the propagating and topworking such hard-wooded fruit trees as litchi, longan, and citrus in Lingnan University, Kwangtung Province, China.

Splice grafting versus cleft grafting.—In cleft grafting the stock is cut to the desired height and then split through the middle forming a cleft, and the scion is cut to a blunt wedge-shaped with one side slightly thicker than the other edge in order to fit the cleft as the wedge-shaped end is inserted with its thicker edge outward, matching well its cambium layer with the inner bark of the stock. On the other hand, in splice grafting only one sharp oblique cut is made on the lower end of the scion and a cut of about the same length is made on the stock and these cut surfaces are brought together with their cambium layers in close contact with each other (figs, 1, *c* and *d*).

Based on the principles that in budding or grafting the union of congenial stocks and scions nowhere else takes place but in their cambium layers, it can be readily seen that a greater amount of such contact is possible in splice grafting than in cleft grafting, besides the fact that splice grafting is considerably easier to perform. In splice grafting the stock and scion are more easily and more fitly matched together and with less amount of lesion to heal than in cleft grafting.

At the present writing some attempts have been made at splice grafting on stocks of about eight months, at a point 5 to 10 centimeters from the ground and without any green leaves below the point of contact. From the high degree of success so far obtained from these trials it may be inferred that the "nurse leaves" below the union may be dispensed with, if and when the grafting is performed at the early stage of the stocks when the lower portion of the stem is still greenish brown and the stocks are in their prime stage of active growth, as shown by the appearance of new flush of leaves. Repeated attempts to cleft graft at this stage also without the "nurse leaves" resulted in utter failure. It must be realized in this connection that grafting close to the ground, with tops removed, when successful, will produce proportionate and sturdy grafts, but the grafting of the stocks that failed to "take" during the first operation is set back too long and oftentimes many of the stocks may die out.

SUMMARY

Briefly, splice grafting consisted of cutting obliquely both the scion and the stock of equal size with both incisions about 4 to 5 centimeters long, a little longer than on the scion, and then joining them with cut surfaces facing each other with

their cambium layers in direct contact with each other. With a bit larger stock than the scion the former is first cut at an angle of 45 degrees at the desired height and the upward cut, a bit shorter than that of the scion, is made on the back side of the stock and the incisions are brought together so as to make their cambium layers coincide as in the above-mentioned case.

In both cases several green leaves are left intact as "nurse leaves" below the cut on the stock. Then a piece of budding tape is wound tightly around and upward from a little below the point of contact until all the incisions are well covered. A piece of fresh banana petiole is slipped over the scion to the full length of the wrapped stem of the stock.

With splice grafting there is a greater area of contact between the cambium layers than with the cleft grafting, yet there is the minimum amount of lesion to heal. Another advantage over cleft grafting is that the splice grafting may be started in the earlier stages of the stocks, from 3 to 5 months old in the nursery when the size of the stocks is considered too small yet for cleft grafting and far too young for budding.

Splice grafting has been employed successfully in topworking mango, serali, tiessa, citrus, and chico.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Showing splice grafting of mango. *a*, Budwood; *b*, prepared scion; *c*, *d*, scion and stock brought together.

A REVIEW OF EXPERIMENTS AND INVESTIGATIONAL WORK ON FILLER TOBACCO

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Long before the Bureau of Agriculture(1) was organized on October 8, 1901, by Act 261 of the Philippine Commission tobacco growing had already been an old established industry. However, when the Bureau of Agriculture was organized, one of the duties assigned to it was to conduct investigations on methods of curing and the improvement of the varieties of tobacco. The Bureau of Agriculture was given charge of the Government agriculture experiment station in Isabela. The Bureau then started the work on tobacco especially in the Cagayan Valley, stressing its tobacco activities, of course, on the filler type. It also conducted work on the wrapper type. As a review was made separately on wrapper tobacco this paper deals with the experiment and investigational work on cigar-filler tobacco only.

VARIETY TEST

This experiment (4) was performed at the Dammao Tobacco Experiment Station. Twelve varieties were used. The plants were set 80 by 80 centimeters apart. Of these 12 varieties, Vizcaya gave the highest yield (49.2) quintals of tobacco per hectare. Anipa Broadleaf ranked second (41.8 quintals); Angadanan, third (41.1 quintals); and Palattao, fourth place with a production of 35.3 quintals. Romero, Dammao Broadleaf, and Dumbara showed the best burning quality; and Palattao, Espada-Dammao, Espada and Bahia had the best aroma. Medium Repollo and the Espada-Dammao were hardy and prolific varieties and adapted themselves to poor soils and late plantings.

The test (16) was conducted at the Ilagan Tobacco Experiment Station. Five foreign varieties were used, two of which, Tall Zimmer and Dutch, belong to the cigar-filler type, while Olsen No. 1, Kavalha, and South African belong to the Turkish type. The result showed that their yields were 1,158, 1,078, 706, 464, and 1,047 kilos per hectare, respectively. With

the exception of the Olsen and the Kavalha the yields were very good. These two varieties, being small plants with relatively smaller leaves, naturally registered low yields.

The seeds of all the varieties used were sown October 10, 1926 in wooden flats, germinating 5 to 7 days later, and the seedlings were all transplanted at the same time, December 26, 1926. The bigger varieties, Tall Zimmer, Dutch, and Olsen No. 1, were set out in the field 70 centimeters apart in the rows and 80 centimeters apart between the rows. The smaller varieties Kavalha and South African were set out 50 centimeters apart in the rows and 80 centimeters apart between rows.

At Pikit and Sarunayan Experiment Station(4) most of the native kinds like Dammao Broadleaf, Espada, Palattao, Repollo, Romero, and others had produced good filler leaves.

The test(4, 6) conducted at the Ilagan Tobacco Experiment Station showed that the Repollo gave the best yield, 37.88 quintals per hectare. Pampano No. 2 followed with 36.36 quintals, then came Pampano No. 4 with 32.77 quintals, Pampano No. 1 with 32.59 quintals, Espada with 31.10 quintals, Vizcaya with 30.65 quintals, and Bahia with 21.86 quintals per hectare.

Another experiment(7, 16) conducted at the same station showed that Pampano No. 2 led in yield with 2,887.5 kilos per hectare, followed by Repollo with 2,607 kilos, Pampano No. 3 with 2,507 kilos, Pampano No. 1 with 2,133 kilos, Tall Zimmer with 1,158 kilos, Dutch with 1,078 kilos, and Bahia with 520 kilos per hectare.

Under this test(9) five varieties were studied, namely, Vizcaya, Pampano No. 1, Pampano No. 2, Repollo, and Espada. The result showed that in yield per hectare Vizcaya ranked highest, with the production of 37.35 quintals; Espada second, with 36.98 quintals; Pampano No. 2 third, with 35.83 quintals; Repollo fourth, with 33.19 quintals; and Pampano No. 1 last, with 25.92 quintals.

In the same station(8) the following varieties were tested: Pampano No. 2, Repollo, Pampano No. 1, Vizcaya, Espada, and Romero. The experiment gave these results: Repollo 1,870 kilos, Pampano No. 1 1,519.8 kilos, Vizcaya 1,115 kilos, Espada 1,000 kilos, and Romero 849 kilos, respectively, of marketable leaf tobacco.

This experiment(8) was conducted at the Ilagan Tobacco Experiment Station, which gave the computed yield per hectare of the different varieties tested—Vizcaya 42.46, Pampano 33.34,

Marogui 39.30, Espada 41.42, Repollo 31.64, Simmaba 33.97, and Sulcok 17.63 quintals, respectively.

At the Los Baños Economic Garden (11) eleven varieties were tested consisting of 4 foreign and 7 native with the yields obtained as follows: Espada 26.57 quintals, Repollo 26.19 quintals, Marogui 25.82 quintals, and Simmaba 25.26 quintals—all native varieties. The foreign varieties were lower in production per hectare.

During the years 1937 and 1938 (11) seven leading varieties of cigar filler varieties, namely, Pampano, Romero, Simmaba, Vizcaya, Marogui, Espada, and Repollo, were grown at the Central Experiment Station, Manila. The yields of the different varieties and strains of tobacco studied varied. However, the varieties Simmaba, Vizcaya, and Marogui were recommended for planting, as under Los Baños condition also these varieties were found to be the best yielders.

For the 3-year period (1936–1938) (11) five imported cigar filler varieties were grown side by side with the highly-yielding varieties at the Los Baños Station. The following table shows the result of the experiment:

Cigar-filler varieties	Yield per hectare		
	1936	1937	1938
	Quintals	*Quintals*	*Quintals*
Jamaica (foreign)	15.79	33.06	48.00
Havana do	16.72	24.55	18.00
Texas Cuban do.	23.83	9.32	9.50
Connecticut do.	16.00	9.20	23.00
State Brazilian do.	16.50	7.00	7.00
Espada (native)	26.57	39.54	52.00
Repollo do.	25.19	14.92	48.00
Simmaba do.	26.16	31.80	56.00
Pampano do.	25.01	24.77	37.00
Vizcaya do.	24.66	23.86	55.00
Romero do.	16.50	17.50	25.00

Jamaica and Connecticut showed good promise as high yielders but their yields judged from the three-year records are inferior to those of either the varieties Simmaba or Vizcaya.

CULTURAL TEST

Seed viability test.—At Dammao Station the experiment (3) on viability test of seeds was carried out in connection with the open beds and the germinating boxes of all the seeds of the different varieties and strains used in the variety and propagation tests. The following points were observed. First under the same conditions, different varieties and strains of tobacco

exhibited different degrees of viability, ranging from 65 to 95 per cent for fresh seeds and from 10 to 50 per cent for 1-year-old seeds. The strains of Espada-Dámmao and Dammao Broadleaf showed as high a germination as 80 per cent when the seeds are stored in well-sealed paper package kept in mason fruit jars. The viability of seeds stored in them fell after one year to about 50 per cent. Second, a very high germination percentage was obtained under controlled conditions as in the case of germination boxes which could be kept safely in shed. The irregularity in weather conditions in the Cagayan Valley was responsible for irregular germination percentages for the same strain or variety in different seasons. Third, provided germination is well controlled, 10 mother plants could easily supply seedlings to plant two hectares of tobacco land.

Seed testing.—At the Ilagan Tobacco Experiment Station (5) it was found that there was to be a difference of almost 200 per cent germination between light and heavy seeds in favor of the latter. The bigger native varieties showed $33\frac{1}{3}$ per cent higher than the smaller exotic varieties. The varieties used were Repollo, Espada, Pampano No. 1, Pampano No. 2, Florida Sumatra, Baker's Sumatra, Bahia, Havana and S. P. No. 2.

Distancing test with Vizcaya variety.—The result of the test (9) showed that the plants set 80 by 40 centimeters and 100 by 50 centimeters, gave the best development and were practically free from diseases. Planting closer than 80 by 40 centimeters was not recommended.

Seasonal tobacco test.—Under La Union condition, (6) it was found that September (latter part of the month), October, and November are the best months for sowing the tobacco seed, and November and December the best time for transplanting the seedlings in the field. In spite of adverse weather condition during the 1925–1926 season the Renta Pugot (Romero), Pampano No. 2, and Repollo came out with promising results.

The general quality of the leaves of the Vizcaya variety planted on December 15 and 28 were better than those which were planted earlier. The leaves of the plants were brittle and without gum. These results were attributed to the rainy condition of the weather during the harvesting period.

Pot fertilizer experiment.—The triangular system of fertilizer test at Ilagan Tobacco Experiment Station (16) was adopted in $8\frac{1}{3}$ per cent stages. Of the 91 possible combinations, actually there were 16 triple combinations regularly

scattered in that triangular system. The variety used was Pampano No. 1. An application of 100 kilos of nitrogen, 40 kilos of potash, and 100 kilos of phosphoric acid per hectare produced the greatest growth.

Determination of the best rate of seeding for transplanting.—The optimum rate of seeding observed was 2 grams per square meter of seedbed. This produced 4,720 seedlings.

The determination of the best age of pricked tobacco seedlings for transplanting.—The result of the experiment (10) showed that the optimum age of seedlings from sowing to transplanting time in the case of the bigger varieties like Simmaba and Vizcaya is around 60 days, and for the smaller varieties like the Philippine Baker's Sumatra, 50 days. Under Southern Mindanao(1) conditions, 45 days was found the best for Baker Sumatra.

The effect of transplanting pricked and unpricked tobacco seedlings of different ages upon growth and yield.—The Simmaba variety (14) was grown in Los Baños Economic Garden, Los Baños, Laguna, during the years 1935 and 1936. The different ages of pricked and unpricked seedlings, ranging from 44 to 86 days old from the date of sowing, were used as planting materials. Of the pricked and unpricked seedlings, the 58-day old produced the highest yield. The seedlings transplanted at the age of 65 days produced yield higher than that of either the seedlings transplanted at the age of 45 days or the seedlings transplanted at the age of 51 days. Pricked planting materials produced yield better than that of the unpricked plants when transplanting in the field is delayed (as late as 72 days). The best stands of tobacco plants were obtained from seedlings transplanted at the ages of between 51 and 65 days.

BREEDING

Hybridization.—The seeds of the hybrids and the parents were sowed in wooden flats on October 10, 1926, germinating 5 to 7 days later. (5, 7, 16) The soil was silty loam on the edge of being clay loam. Lime was applied at the rate of 1,000 pounds per hectare about a month before transplanting. The resnlts showed that the two F_1 hybrids (Romero $\times$ Repollo and Romero $\times$ Philippine Sumatra) behaved as intermediate types between their two respective parents.

Standardization of varieties and strains.—The original stock of 11 varieties and strains was reduced to 8 for convenience. (5 and 15). Pampano Nos. 1, 2, 3, and 4, Espada Repollo,

Vizcaya, and Romero were used. The characters statistically studied showed fair means, standard deviation and coefficient of variability. The height of the plants varied. Pampano Nos. 1 and 2 gave the broadest leaves and the best yields, Espada the narrowest leaves and Repollo medium leaves, the Vizcaya and Romero aromatic leaves. Pampano Nos. 3 and 4 were not heavy yielders but have the finer veins.

The varieties used in this experiment (13) were Pampano, Marogui, Vizcaya, Espada, and Romero. The work was first conducted at Ilagan Station, continued at Alabang Station, and concluded in 1933–1934 and 1934–1935 seasons at the Central Experiment Station, Manila. The result showed that continuous selection increased the yield of Pampano, Repollo, Espada, and Romero. Repollo gave the average yield of 40.3 ± 1.62 quintals per hectare. The difference in the results obtained for the different seasons of any single variety is largely due to the existing climatic conditions.

Pedigree work.—One thousand eighty-seven (1,087) pedigree (4, 5) selections were made representing 14 varieties and strains. Continuing the work started at Dammao, the Ilagan Station made attempts to obtain pure lines from a number of varieties possessing certain good qualities, among other important points the high productivity and general quality of leaf of the filler. There were 18 varieties and nearly 100 lines included in the test.

The following table shows the performance of crosses (11) made on cigar-filler hybrids.

Hybrids	Generation	Yield per hectare		
		1936	1937	1938
		Quintals	*Quintals*	*Quintals*
Vizcaya X Simmaba	F_3	26.09	13.02	24.40
Sumatra X Vizcaya	F_3	25.78	14.09	20.40

The yields of the hybrids varied in the three-year results of the experiment.

PHYSIOLOGY

Physiology of priming time.—There were indications (5) pointing to the successful production of light glossy leaves by priming a little before the maturity stage of the leaves.

Optimum soil moisture for tobacco.—A preliminary test (8) using alluvial and garden soils separately showed that the optimum requirement for tobacco is 60 per cent soil moisture.

Water requirement experiment.—This was a pot experiment(7, 16) utilizing petroleum cans and two kinds of soils—alluvial and common garden (clay loam). The soils were first air-dried and later dried in the laboratory oven for 24 hours. They were reweighed to determine the amount of moisture still present after being air-dried. This is to facilitate the measurement of water to be added to each pot to make the different saturations. Of this experiment Pampano No. 1 was used. One hundred per cent, 80 per cent, 60 per cent, 50 per cent, 30 per cent, and 5 per cent saturation were tried.

Peralta found that 60–70 per cent saturation gave the best result.

Studies on the salt requirement of tobacco.—The result(10) showed that under controlled condition (sand culture) tobacco prefers the nitrate form of nitrogen to the ammoniacal form.

With tobacco (sand culture), optimum growth was obtained when the total molar concentration of all salts taken together KH_2PO_4, $Ca(NO_3)_2$, $Ca(H_2PO_4)_2$, and $MgSO_4$ was 0.0132.

Nicotine content of some cigar-filler varieties.—The eleven varieties(17) of the cigar-filler type were raised in Los Baños Economic Garden, Los Baños, Laguna, and in the Central Experiment Station, Manila, during the 1938–1939 tobacco season. From this crop sufficient samples of cured (not fermented) were prepared for nicotine-content determination.

Of this experiment the varieties Espada, Havana, Pampano, Repollo, Romero, and Vizcaya were found to contain nicotine for the lamina as much as 1.37, 1.83, 1.37, 1.67, 1.84, and 1.07 per cent, while the midrib 0.11, 0.11, 0.18, 0.29, 0.22 and 0.13 per cent, respectively. The nicotine ratio of lamina to nicotine of midrib is approximately 9 to 1. Jamaica, an imported variety from the United States, contained the highest amount of nicotine, 2.05 per cent. The varieties Simmaba, Vizcaya, Repollo, Espada, and Romero were found to contain 1.16, 1.07, 1.67, 1.37, and 1.64 per cent nicotine, respectively, when grown under Los Baños conditions. The leaves of tobacco grown in Los Baños, Laguna, contained higher nicotine than those plants grown in the Central Experiment Station, Manila. The average nicotine contents of the leaves of 11 different tobacco varieties were 1.556 and 1.28 per cent for lamina, grown under Los Baños and Manila conditions, respectively, or about 0.276 per cent difference.

CURING EXPERIMENT

This experiment (3) was conducted at the Dammao Experiment Station in order to compare the modified native with certain foreign-approved methods—(*a*) face to face and back to back, (*b*) face to back, and (*c*) Cuban in which the leaves are pierced with twine so that they ride alternately on the poles. The control are the native methods of (1) partially curing the leaves in the sun and afterwards hanging them up in the curing shed and (2) partially sun drying and afterwards hanging them under the house.

The result showed that all the methods tried with the exception of the two alternative methods were satisfactory. With the Cuban method, the leaves cured one day earlier but this difference is insignificant. The method followed is a sort of the modified method. The leaves were strung side by side, folded in palillos capable of holding at least 50 leaves and allowing a finger breadth, between the leaves. The leaves were racked directly into the shed for complete shade and slow curing. This method showed as favorable results as the approved foreign method.

Another experiment (4) was performed using six different varieties. The result showed that the leaves cure more or less in the same way under different methods used. Also mold almost always formed on the leaves when the palillos are removed from the curing shed to the warehouse while the midribs were not thoroughly dry.

Also the curing studies (7) were conducted at the Ilagan Tobacco Experiment Station with the use of the varieties, Romero, Kavalha, and South African. The observation made was on the effect of topping the varieties.

The result indicated that low topping and late harvesting were conducive to lighter colors and more pronounced aroma. It was also observed incidentally that at 86 per cent relative humidity, curing shed disease began to appear and affected the curing leaves.

COST OF PRODUCTION

Paguirigan et al. (1) found out that the total cost per hectare averaged ₱397.43 in Ilagan, ₱366.55 in Echague, and ₱303.07 in Tuguegarao. The average cost per hectare for the 235 farms represented in the survey in the Cagayan Valley was ₱349.15.

The cost of producing filler tobacco with the plant set 70 by 80 centimeters was ₱483.50 per hectare. When planted 90 by 90 centimeters at the rate of ₱1.00 per man-labor, ₱0.50 for animal-labor, and ₱1.00 per woman labor is ₱570.00 per hectare including cost of seed, depreciation of curing barns, palillos and incidental expenses, but for the same distancing for labor of man, woman, and animal at the rate of ₱0.50 each, amounted to ₱244.00.

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PROGRESS REPORT ON THE EFFECT OF PRUNING ONION SEEDLINGS ON THE YIELD[1]

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INTRODUCTION

Importance.—Pruning of onion seedlings in the Philippines dates back to the introduction of the big bulbed onion here. Either the roots or tops or both were trimmed. The last treatment is the more popular. As the industry expanded, the convenience of handling pruned seedlings in transplanting became so well known that pruning became the practice of onion growers, unmindful of its possible harmful effect to the plant itself. Pruning is recommended to facilitate handling during transplanting operations; but pruning any part of a plant affects its development and the resulting yield, the extent of the effect being dependent upon the location and degree of injury. For best results, a pruning treatment which does not greatly affect the yield is most desirable. The results of the present study show such pruning treatment.

Review of literature.—No literature on local studies related to the present experiment was available. It may be stated in this connection that immediately prior to World War II, Mr. Pedro A. Rodrigo, chief of the Horticulture Research Section of the Bureau of Plant Industry, had already a one-year test on the effect of pruning onion seedling on its yield. The results of this study together with other data were lost when the buildings of the said Bureau were burned. The results, according to Rodrigo, indicated that pruning either the leaves or roots or both had a deleterious effect on bulb production. Seedlings with tops clipped off had a slow recovery and their growth and development were inferior to those of unpruned seedlings.

[1] Study conducted at the provincial nursery, Laoag, Ilocos Norte, by the Division of Horticulture-Agronomy, Bureau of Plant Industry, under the direction of Mr. Pedro A. Rodrigo, chief, Horticulture Research Section.

Davis and Jones [2] (1944) conducted pruning experiments in 1930, 1931, 1934, and 1942, at Davis, California. Early Red 21–24 produced larger bulbs and a greater yield without pruning than with pruning. Cutting back both roots and tops of an individual plant reduced the weight of the mature bulbs. Pruning either the roots or the tops gave the plant a less severe check than pruning them both. Root pruning seemed to produce the least injury (1930). In 1931 these writers found that the differences in weight of bulb between the various treatments were not significant. Unpruned seedlings and those with only the roots pruned produced the heaviest bulbs. In yield per acre the transplants with both roots and tops trimmed yielded significantly less than the unpruned or those with only the roots pruned. In 1934, they found again that the unpruned lots were significantly heavier in both weight per bulb and yield per acre than those of other treatments; and, as before, the seedlings with both tops and roots pruned made the poorest showing. In 1942 they used two varieties in their studies. Of San Joaquin variety, they found that there was no significant difference neither in the mean weight of bulbs from the different treatments nor in the yield per acre, though there was a significant difference between the number harvested per plot and the mean weight. However, the yield per acre from transplants with both roots and tops pruned was significantly lower than the yield from any other treatment.

Object.—The object of the present experiment was to find out to what extent each of the pruning treatments tried affects the yield and the weight of the bulb produced.

Time and place.—The study was conducted at the provincial nursery grounds at Laoag, Ilocos Norte, during the period from October, 1947 to April, 1948.

MATERIALS AND METHODS

The Red Globe variety of onion, the seeds of which were imported from India, was used in the experiment.

The seeds were sown in seedbeds about the later part of October, 1947; transplanted about the later part of December, 1947; and the bulbs were harvested about the middle of April, 1948.

The preparation of the field and the culture for the production of market onions were followed and applied to all the

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[2] Davis, G. N., and H. A. Jones. Experiments with the transplant onion crop in California. University of California Agric. Experiment Station Bull. No. 682 (1944) 13–15.

treatments in as uniform a manner as possible. Fertilizer, ammonium sulphate, was applied by the broadcast method at the rate of 150 kilograms to the hectare.

The treatments given were (*a*) unpruned, (*b*) roots pruned, and (*c*) roots and tops pruned. Four replications were made. The field was divided into two by a path of one meter wide along the center from north to south. The plots were marked at right angles to the central path at intervals of sixty centimeters. Three rows were marked in each plot and the seedlings were planted 15 centimeters apart in the rows. There were 180 seedlings in each plot and every plot was given different treatments. The plots were alternately arranged in such a manner that the different treatments were equally distributed throughout the entire field.

Harvesting.—The bulbs in all the plots were harvested on the same day, April 19, 1948. The harvests from each plot of treatment were separated and labeled accordingly. After the bulbs were properly cured, the labeled harvests were separately weighed. The number and weight of bulbs harvested from each plot of treatment were recorded.

To determine the size of bulb produced by the different treatments, fifty representative bulbs were selected from each plot, weighed individually and the weights were recorded.

RESULTS

All the plants of the different treatments were attacked by thrips and blight disease of onions. The thrips were controlled with DDT kerosene emulsion, sprayed at weekly intervals, but the disease could not be controlled due to lack of lime sulphur spray.

Table 1 shows the number and the weight of bulbs harvested per plot of the different treatments.

TABLE 1.—*Showing the number and the weight of bulbs per plot.*

Plot number	Area per plot	Plants per plot	Planted	Harvested	Bulbs harvested per plot — Pruning treatments			Weight of bulbs per plot (kilos) — Pruning treatments		
					Unpruned	Roots	Roots and tops	Unpruned	Roots	Roots and tops
	sq.m.		*1947*	*1948*						
1	10	180	Dec. 30	April 19	128	116	103	3.60	2.67	1.84
2	10	180	do.	do.	130	113	118	3.44	2.27	2.59
3	10	180	do.	do.	124	126	111	3.32	3.02	2.54
4	10	180	do.	do.	119	126	108	3.24	3.44	2.26
				TOTAL	501	481	440	13.60	11.40	9.23
				Mean	125.25	120.25	110.00	3.40	2.85	2.31

The weight per bulb per plot produced by each treatment was taken and recorded in Table 2.

TABLE 2.—*Average weight (grams) per bulb per plot.*

Plot number	Unpruned	Roots pruned	Roots and tops pruned
1	28	23	20
2	26	22	22
3	26	21	21
4	27	27	21
Mean	26.75	23.25	21.00

Table 3 shows the comparisons made in the mean number of bulbs harvested per plot under each treatment.

TABLE 3.—*Comparison of yield in number.*

Treatment number	Treatments	Mean number of bulbs per plot	Comparison	Difference
1	Unpruned	125.25±1.638	1:2	5.00±2.804(S)
2	Roots pruned	120.25±2.277	2:3	10.25±3.107(S)
3	Tops and roots pruned	110.00±2.115	1:3	15.25±2 675(S)

(S), Significant

The mean weight of bulbs per plot of the different treatments was statistically compared as shown in Table 4.

TABLE 4.—*Comparison of yield in weight.*

Treatment number	Treatments	Mean weight of bulbs per plot in kilos	Comparison	Difference
1	Unpruned	3.40±0.053	1:2	0.55±0.176(S)
2	Roots pruned	2.85±0.168	2:3	1.09±0.204(S)
3	Tops and roots pruned	2.31±0.116	1:3	0.54±0.128(S)

(S), Significant

Table 5 shows the comparisons made in the mean weight per bulb produced by each treatment.

TABLE 5.—*Comparison of size by weight per bulb.*

Treatment number	Treatments	Mean weight per bulb in grams	Comparison	Difference
1	Unpruned	26.75±0.322	1:2	3.50±0.947(S)
2	Roots pruned	23.25±0.890	2:3	2.25±0.932(S)
3	Tops and roots pruned	21.00±0.275	1:3	5.75±0.424(S)

(S), Significant

DISCUSSION OF RESULTS

Although the blight disease of onions which infected all the plants of the different treatments could not be controlled owing to the lack of lime sulphur spray, the plants in all the plots continued to form, develop, and mature bulbs. Since the degree of infection was more or less uniform in all the treatments, the data gathered in these experiments were considered by the author as normal and consistent. The differences in the stand exhibited by each plot of plants could have been due to the treatments given them.

The plants in all the treatments matured at more or less the same time. This shows that the maturity of the plants under each treatment was not affected by pruning.

The number of bulbs harvested per plot from the different treatments ranged from 119 to 130 bulbs, with an average of 125.25 bulbs for unpruned plots; from 113 to 126 bulbs, with an average of 120.25 bulbs, for plots with only the roots pruned; and from 103 to 118 bulbs, with an average of 110 bulbs for plots with both the roots and tops pruned (Table 1). Statistical comparisons were made among the averages in the number of bulbs harvested per plot of the different treatments (Table 3). The unpruned plots gave significantly more number of bulbs than those of other treatments. The plots with only the roots pruned gave significantly more bulbs than the plots with both the roots and tops pruned, thus showing that pruning the roots and tops produced lesser yield.

The weight of bulbs harvested per plot from the different treatments varied from 3.24 to 3.60 kilos, with an average of 3.40 kilos of bulbs from unpruned plots; from 2.27 to 3.44 kilos, with an average of 2.85 kilos of bulbs from the plots with only the roots pruned; and from 1.84 to 2.26 kilos, with an average of 2.31 kilos of bulbs from plots with both the roots and tops pruned (Table 1). There were significant differences among the averages in weight of bulbs per plot from the different treatments (Table 4). The unpruned plots gave significantly the greatest yield by weight among the treatments. The plots with only the roots pruned gave significantly heavier yield by weight than the plots with both roots and tops trimmed. As before the plots with both the tops and roots trimmed exhibited the poorest showing.

Fifty bulbs (representative) from each plot were individually weighed to determine the sizes of bulbs produced by

the different treatments and from these weighings, the average weight per bulb per plot was determined (Table 2). The average weight per bulb per plot ranged from 26 to 28 grams, with an average of 26.75 grams per bulb for unpruned seedlings; from 21 to 27 grams, with an average of 23.25 grams per bulb for seedlings with only the roots pruned; and from 20 to 22 grams, with an average of 21 grams per bulb for seedlings with both the roots and tops trimmed (Table 2). Statistical comparisons were made of the mean weight per bulb of the different treatments (Table 5). Unpruned seedlings produced larger bulb than the pruned seedlings. However, seedlings with only the roots pruned produced larger bulb than those with both the tops and roots pruned. This shows that the size of bulb was greatly reduced by trimming both roots and tops.

SUMMARY AND CONCLUSIONS

1. This paper presents the result of a year study on the effect of leaf and root pruning of onion seedlings before planting.

2. Three treatments were applied, namely, (*a*) unpruned, (*b*) roots pruned, and (*c*) roots and tops pruned.

3. All seedlings of the different treatments were transplanted on the same day, December 30, 1947 and all matured bulbs were harvested also on the same day, April 19, 1948. Pruning treatment was found not to affect the maturity of the bulbs.

4. The preparation of the field and culture for the production of market onions was followed and applied in as uniform a manner as possible to all the treatments. Ammonium sulphate at the rate of 150 kilograms to the hectare was applied by the broadcast method.

5. Fifty bulbs were selected from each plot and each bulb was individually weighed to determine the average weight per bulb per plot.

6. The yield by number of weight of bulb harvested per plot of the different treatments varied from 119 to 130, with an average of 125.25 bulb or from 3.24 to 3.60, with an average of 3.40 kilos of bulbs from unpruned plots; from 113 to 126, with an average of 120.25 bulbs or from 2.27 to 3.44, with an average of 2.85 kilos of bulbs from plots with only the roots pruned; and from 103 to 118, with an average of 110 bulbs

or from 1.84 to 2.26, with an average of 2.31 kilos of bulbs from seedlings with both the roots and tops trimmed.

7. Statistical differences in yield by number and weight of bulbs harvested per plot were found among the averages of the different treatments. The unpruned plots gave significantly heavier yield both in number and weight of bulbs than any of the other treatments. The plots with only the roots pruned gave significantly greater yield both in number and weight of bulbs produced than the plots with both the roots and tops trimmed. The plots with both the roots and tops pruned gave significantly the least yield among the treatments given.

8. The sizes of bulb, by weight in grams, per plot ranged from 26 to 28, with an average of 26.75 grams produced by unpruned seedlings; from 21 to 27, with an average of 23.25 grams from seedlings with only the roots pruned; and from 20 to 22, with an average of 21 grams from seedlings with both the roots and tops trimmed. Significant differences among the averages in weight per bulb existed. Unpruned seedlings produced the biggest bulbs, followed by the seedlings with only the roots pruned, and the least size of bulb by the seedlings with both the roots and tops pruned. This shows that cutting back both tops and roots of an individual plant reduced the size by weight of the matured bulb, and that root pruning produced the least injury.

VIRGINIA TOBACCO CULTURE

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ONE PLATE AND ONE TEXT FIGURE

In 1948 the Philippines imported 11½ billion units of aromatic cigarettes worth over 57 million pesos. These figures are staggering for three reasons:

1. The value of imported aromatic cigarettes is greater than the total prewar value of Philippine leaf tobacco production and manufactures thereof.
2. It is greater than that for all other imported tobacco leaf and manufactures thereof.
3. The huge number of imported aromatic cigarettes into this country is almost one-half of the total United States cigarette exportation to the whole world—25 billion units.

Therefore, there are both large business and much money for the country if she embarks in this highly specialized industry and properly adopts the methods or processes of culture, reconditioning, packing, aging, and the modern manufacture of aromatic cigarette blends, similar to those in vogue in the United States.

This paper, however, deals only with the culture of Virginia tobacco, the basic and principal component of aromatic cigarettes.

Varieties.—The best varieties found adapted in the Philippines are North Carolina Bright Yellow, Gold Dollar, Cash, Eastern Carolina, and Warne. Other varieties are in the process of trial tests. Plate 1 is a sample of the Virginia tobacco type thriving well under Philippine conditions.

Climate.—The climate required by the Virginia tobacco is the first type with two pronounced seasons, dry in December to May and wet in June to November. The provinces and regions having this climate which may grow this tobacco are: Western Abra, Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Tarlac, Pampanga, southern Koronadal Valley in Cotabato, southern Iloilo, Antique, and southern Occidental Negros.

Soil.—The soils best adapted for Virginia are sandy and silty soils, containing the least clay, rather poor in nitrogen, fair in phosphoric acid and rich in potash contents. This soil requirement will insure fine textured leaves of light body and ease of curing with the desired yellow color.

Season.—The seasonal periods for the different field and warehouse operations, depending upon the locality, are as follows:

Seedbed period	September 1 to October 31
Transplanting period	October 15 to December 15
Development period	November to January
Harvesting and flue-curing period	January to April
Reconditioning	February to May
Aging	Two years.

The last two warehouse processes should belong to the buyer or manufacturing firm.

Seedbeds.—An exposed high ground, rich in humus, preferably new, near a water supply and with a good drainage should be selected for seedbeds. Virgin land, if available, is to be preferred. The land should be plowed and harrowed several times and put in the best of tilth. It should be divided into standard size beds, preferably 10 meters long and 1.2 meters wide, running north to south and uniformly laid out. Between beds (lengthwise) there should be straight paths 50 centimeters wide which also serve as drainage canals. Between columns of beds (endwise), the paths should be 90 centimeters. Each bed should be provided with a cover or roof of nipa shingles, cogon, or talahib facing east in order to protect the beds from strong sunlight and heavy rains. The roof inclination should be 30 centimeters; that is, 6 front posts are 1.2 meters long and back posts 90 centimeters long. The soil of the paths should be lifted and placed on the beds. Final preparation of the beds should be made with hand tools. To insure rapid, thrifty, and stocky growth of seedlings one kilo of the fertilizer mentioned below should be uniformly spread and raked in for 5 centimeters on each bed before sowing.

Seeding.—Three to seven grams (roughly one teaspoonful to one tablespoonful) of seeds, depending upon percentage of germination, mixed with a chupa of sifted wood ashes, fine sand, or dry fine earth, are scattered sparsely and evenly on each seedbed. As the seeds are small, it is not necessary to cover them with earth. Tamping the surface is also unneces-

sary. The beds are sprinkled carefully with water not allowing it to flow over, preferably from wells dug near streams. The soil should be kept moist at all time, but not too wet. Each seedbed can produce at least 2,000 healthy and stocky seedlings. Ten to 12 beds are sufficient for 1 hectare.

Care of seedlings.—The seedlings will appear 6 days after sowing. Twenty-five to 30 days after sowing, the portions of the beds showing thick growth should be thinned out, spacing seedlings 5 centimeters each way. The good seedlings removed should be pricked to bare portions of the bed or those with sparse growth. If pricking is done, the front part of the beds should be covered to cut off the sun 1 day or 2 days. The bed covers should be removed 7 to 10 days before transplanting in order to harden the seedlings and to accustom them to field conditions. To free the seedlings from worms, the beds should be sprayed weekly with 1 per cent calcium or lead arsenate solution (one condensed milk can of calcium or lead arsenate in 1 petroleum can of water) using a hand or knapsack force pump for the purpose. Stir the solution every time the pump is loaded. A thin white coating of the spray on the seedlings is sufficient.

Preparation of the field.—While the seedlings are growing, the land, having been cleared of weeds, brush, and stumps, should be plowed twice or thrice and harrowed as many times before transplanting.

Transplanting.—Virginia varieties being early maturing, from 45 to 50 days after sowing, the seedlings should be ready for transplanting. Unduly delayed transplanting produces a poor crop. The beds should be soaked with water so as to soften the soil. Seedlings of uniform size should be dug early in the morning with trowels, taking care that as much soil as possible adheres to the roots, and with the least injury to them. The seedlings are placed in shallow baskets and protected from the sun and wind in order to keep them fresh and turgid. Transplanting should be carried on in late afternoons, but if the weather is cloudy or showery, the work can be done any time of the day.

Furrows should be made 80 centimeters apart. With a trowel and a string marked at 60 centimeters holes are dug alongside the marks in the furrows and the soil is pulverized sufficiently to have good settings for the plants. With this spacing, one hectare will require about 20,800 plants.

The seedling is placed in the hole no deeper than in the seedbed, with the roots spread out, never twisted or curved, and the surrounding soil pressed evenly and lightly by the hands. If the soil lacks moisture, a tumbler of water is applied to every plant after transplanting in order to hasten recovery. If the days following transplanting are sunny and dry it may be necessary to cover the seedlings with pieces of banana sheaths or other covering material. Endeavor to produce a uniform stand of the crop. Transplanting should be carried out rapidly. About a week after transplanting, dead or dying seedlings should be pulled out and the land replanted.

Fertilization.—If the soil is very poor because of continuous tobacco cropping, an application of 10 to 20 tons of farm manure per hectare may be sufficient. If manure is not available, a complete fertilizer of the formula $4N–8P_2O_5–10K_2O$ may be applied in bands 10 centimeters from each side of the plants. It is preferable to open small shallow furrows 10 centimeters deep for the fertilizer bands and covered. The rate of application should be from 200 to 300 kilos per hectare.

Cultivation.—When the plants are well established, 2 to 3 weeks after transplanting, the first cultivation should be made with small-toothed cultivators. A second cultivation may be made when the plants are 30 centimeters high. Thereafter the rows should be ridged by means of the plow. Final fixing and rounding the ridges may be made by laborers who are to remove weeds close to the plants which were not killed by the cultivation or ridging operations.

Worming.—Besides hand picking of worms in the mornings and late afternoons, the plants should be dusted with calcium arsenate-road dust or calcium arsenate-ash mixture (one part of calcium arsenate to 16 parts by volume of sifted fine road dust or 30 parts of well-burned rice-hull ashes and finely pulverized), using a hand duster, or a cheesecloth bag, or a bamboo tube duster fitted at one end with 1/16 to the inch mesh wire netting. The other end fitted with a handle should have a node but with a slit at the side just below the node for loading the mixture.

If the attack of worms is serious, 1 part of calcium arsenate and 5 parts by volume of either fine road dust or finely pulverized rice-hull ashes are used.

Seed selection.—Before the plants are topped, the most uniform, healthy and true to type should be selected for seed

production. They should be bagged using No. 12 or No. 16 Manila paper bags, supported by poles before the flowers open to insure self-pollination. The bags are removed after all pods are formed. Bagging can be dispensed with when there is only one variety grown and topping and suckering have been thoroughly done. When the pods are matured, the seed heads should be cut off, bundled in bunches and hung to dry in the shed.

Topping.—As a rule Virginia tobacco should be topped. This somewhat delayed topping should be done below the second flower branch with leaves. Thereafter all branches and suckers should be pinched off with the fingers as they appear.

Harvesting.—From 45 to 55 days after transplanting, when the lowermost leaves show signs of ripeness, such as swollen appearance, yellow specks on the tips, margins, and other parts of the lamina, brittleness, noticeable change in color from green to light green, the leaves should be harvested by priming; that is, picked as they ripen. The grower may pick from one to three leaves from a plant at a time, depending upon their maturity. For convenience and ease in flue-curing, the following precautions should be observed:

1. Leaves enough to fill the barn in one day should be harvested in the morning.

2. Care should be taken to harvest leaves of almost the same degree of ripeness.

3. Leaves of the same regional classification should be harvested and cured; that is, (*a*) sand leaves with sand leaves only; (*b*) lower standards with lower standards only; (*c*) middle standards with middle standards only; etc. By virtue of their size, texture, and moisture contents, these different regional classes of leaves require different number of hours and maximum temperature to cure. This requirement is on ascending scale from the finest sand leaves to the coarsest thick-textured top leaves.

4. It should be borne in mind that the desired aim in curing Virginia tobacco is to make all the leaves turn yellow about the same time. If every charge or load of leaves in the flue-curing barn shows all the gamut of greens, yellows, browns, dark browns, mottled, and scalded leaves, such condition is the result of poor and unprofitable curing. When the leaves turn brown, the yellow color is forever lost.

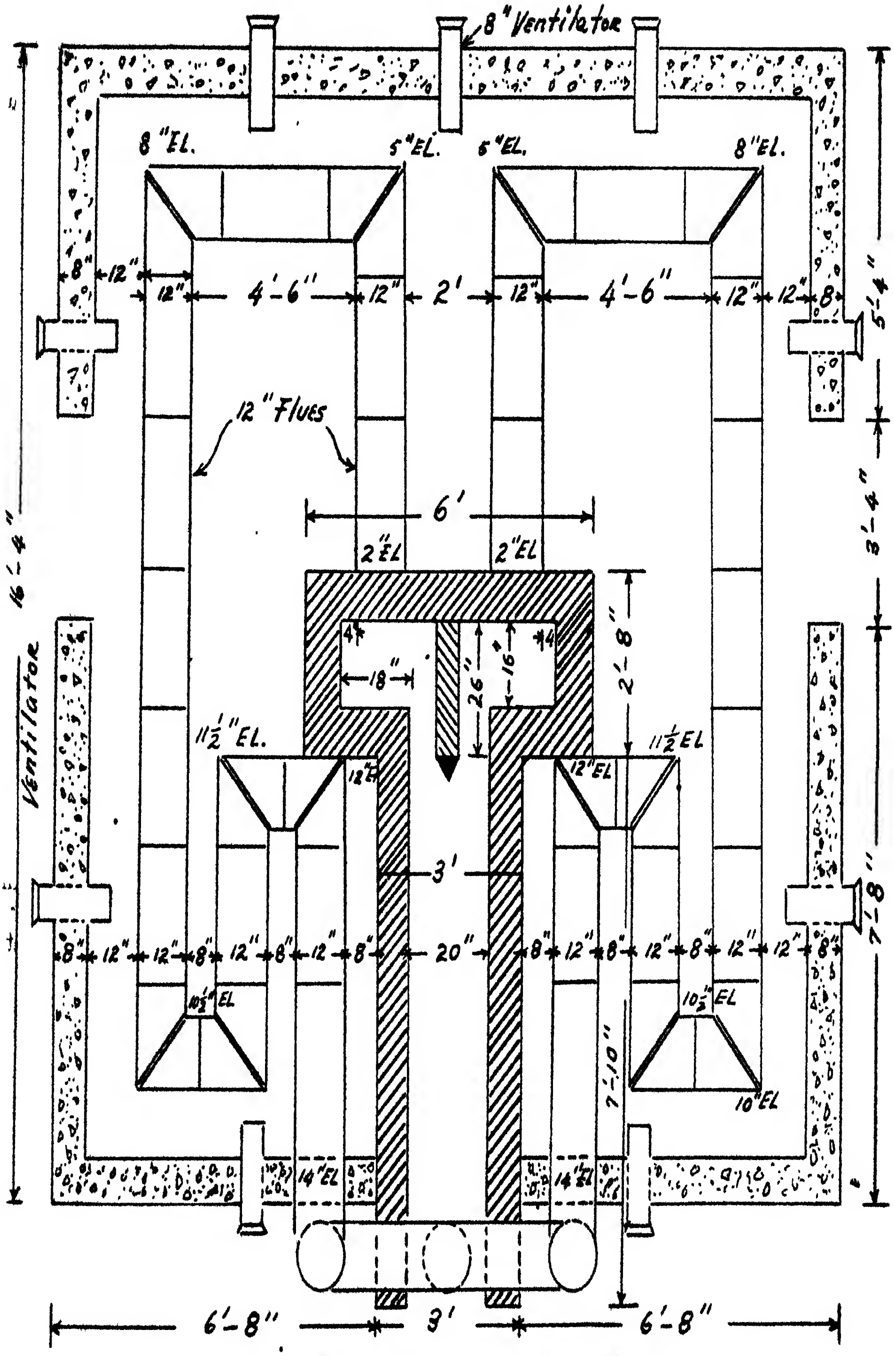
Stringing and poling.—For convenience the tobacco poles should be 1 meter long. The tobacco is strung by means

of a needle face to face and back to back, allowing one to two-finger space between leaves. Twenty-five to thirty leaves should be placed on every pole. To prevent sagging, the string of tobacco may be tied with a piece of twine at the middle of each pole.

Flue-curing barns.—Flue-curing barns are the smallest tobacco curing barns known, being conveniently 4 or 5 meters square (13.1 to 16.4 feet square) and 4 or 5 meters high, but are somewhat exacting in their construction (see text figures). The first requisite is that a barn is capable of being hermetically sealed, with the least effect of outside conditions and with provision for ventilation above and with equally distanced small ventilators or vents on the walls close to the ground. The upper ventilator is preferably located at the whole length of the ridge: either a movable ridge (up and down) with a 4-inch clearance, or a fixed elevated ridge with openings and closings on both sides. This ventilator should be so contrived as to be capable of being operated from below. The barn should be so constructed as to forestall fire hazards. At one side is a kiln with stout iron grate (1 inch diameter) (parilla) to receive the ashes below them and to provide air draft, when necessary. Obviously, the kiln should have an upper and a lower iron doors: the division being in line with the grate. The brick kiln extends more than half of the barn in the form of T from the ends of which are two flues, 12 inches in diameter of iron or of very thick plain galvanized iron, preferably No. 18 gauge. Each of these flues extends to the opposite end, gradually rising and turning to the sides of the barn one foot from the walls and then connecting to the chimney above the kiln for the exit of smoke, as shown in the ground plan. The end view showing the construction of the kiln with its grate and doors and the construction detail of the upper (ridge) ventilator and the side view are shown also in the plan. For obvious reasons, all dimensions are in feet or inches. The lower wall of this barn is of concrete, 8 inches thick. The lower ventilators of 8-inch diameter pipes are equally distanced.

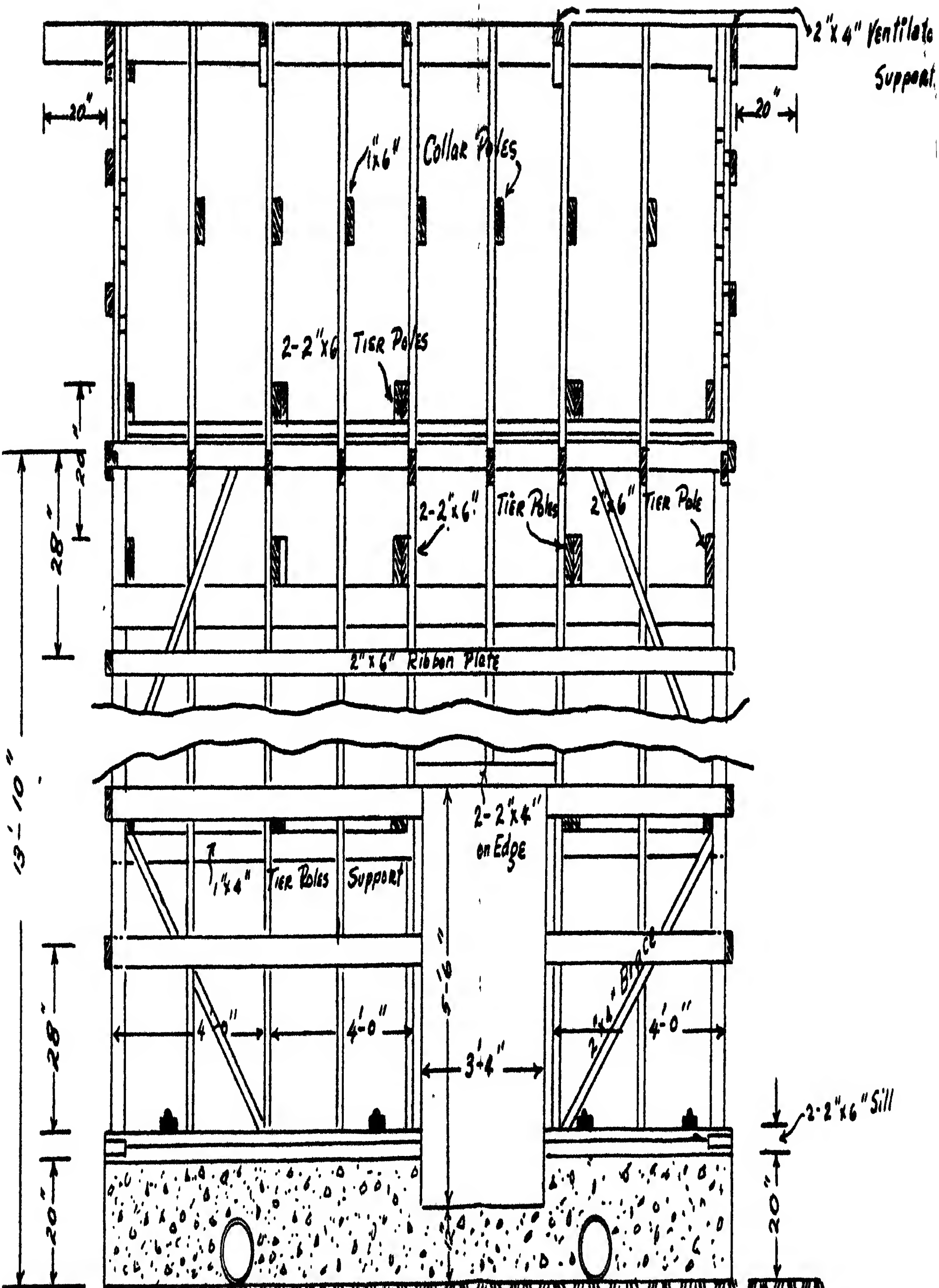
The barn described can cure the produce of one-half or one hectare if the planting is extended at biweekly intervals of one-third to one-half hectare each.

The ideal permanent flue-curing barn should have walls of brick, thick reinforced concrete or adobe stones, and galvanized iron roof, resting on lumber as ceiling. But with the requisites fulfilled, flue-curing barns can be improvised with double walls



A, Ground plan of the flue-curing barn. (Scale: 3/8"=1'.)

Facing page 286.



B, Side view of the flue-curing barn. (Scale: 3/8"=1'.)

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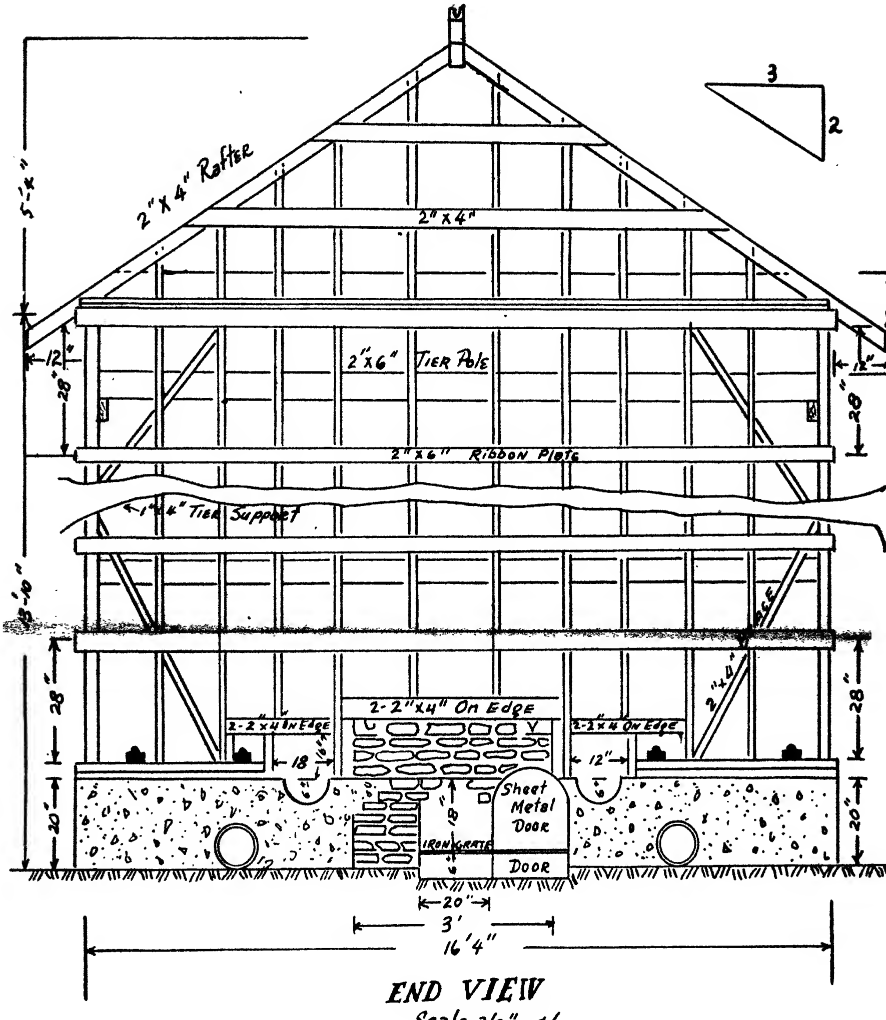

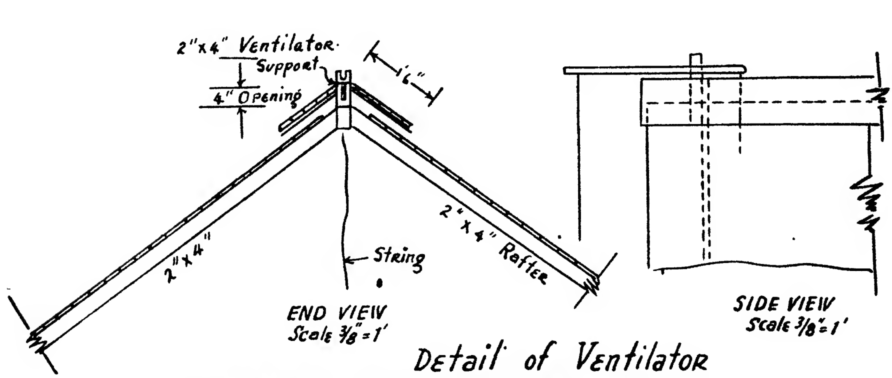

C, End view and detail of ventilator of the flue-curing barn. (Scale 3/8"=1'.)

Facing page 280.

well-dried and properly fit T & G lumber or of double sawali with dung and mud mixture between them except that section where the kiln and the chimney are located, which should be made of fire-proof material.

Flue-curing is the most exacting and difficult process in Virginia tobacco culture. Artificial as it is, it is intended to cure the leaves yellow. This requires experience. No one set of definite rules, especially with respect to the series of temperatures and number of hours required can be given, as each charge or load of leaves in the flue-curing barn differs in texture, body, maturity and water content; likewise, the outside temperatures and humidity differ from day to day. All that can be given here are the minimum and maximum limits of temperature and number of curing hours, expecting the farmer to vary, adjust or decide things as the condition of the tobacco in process of curing warrants.

The farmer should bear in mind the three important stages in flue-curing Virginia tobacco. These are (1) yellowing, (2) fixing the yellow color, and (3) drying the leaves.

The following procedures and precautions are given merely to serve as guides and have to be varied, as herein stated:

Procedures.—1. The fire should be started preferably in the evening as soon as the barn has been filled with sticks of tobacco leaves. The temperature inside, from 29°C. to 38°C., should be made higher gradually than the temperature outside by from 3°C. to 5.5°C. This temperature should be maintained from 24 to 36 hours until the leaves are fairly yellow.

2. Then the temperature should be raised from 2°C. to 3°C. every hour to 48°C. to 52°C., depending upon the rapidity with which the green color has faded. The leaves should be pale yellow by this time. From the start of curing to this stage the upper ventilators and lower vents are closed.

3. Next the temperature should be raised from 2°C. to 3°C. each hour until 54°C. to 60°C., which temperature is maintained until the tissue of the leaves is dry. During this stage the yellow color is fixed. During this period all ventilators and vents are open.

4. The moment the tissues of the leaves are dry, the temperature is raised again from 3°C. to 5°C. each hour to 82°C. to 90°C. This heat is maintained until the midribs are dry throughout the barn. The ventilators are gradually closed and later completely closed in order to attain the high temperatures.

In the Philippines to cure a barn by this procedure takes from 54 to 90 hours.

As a guide the farmer should make a table, with a column of standard temperatures to follow for every charge of leaves and another column to jot his hourly reading of actual temperature registered in the barn.

Precautions.—(*a*) Weather conditions and texture of the leaves and other factors may require shortening or prolonging any of the periods.

(*b*) Raising the temperature too fast while the humidity is high, results in greenish and mottled colors.

(*c*) At 74°C. to 77°C. the humidity in the barn should be low and all ventilators closed.

(*d*) At the conclusion of curing, the ventilators, vents, and door should be opened in order to admit humidity for having the leaves "in case"; that is, with the right moisture and pliability for handling.

(*e*) The leaves should be tied in bundles of 25 leaves, using one leaf for tying and covering the butts. Before they are tied the leaves should be classified into lemon yellow (the best), orange yellow, brownish yellow, mottled colors, green, and packed separately.

(*f*) The bundles should be placed in containers that are hermetically sealed to protect them from excessive moisture. Remember, excessive moisture in the leaves and heating due to fermentation will change the yellow to brown.

(*g*) Virginia tobacco is never fermented; in lieu thereof, after reconditioned, it is aged for 2 years at least.

Re-curing treatment of leaves dried green.—Through untoward circumstances, the leaves may cure green instead of yellow. There is still hope to turn this green color to yellow, as it is hopeless to turn brown to yellow. The writer partially succeeded in this by the following treatment: All the green bundles are separated and allowed to acquire more moisture than necessary for packing by exposure in the moist atmosphere or in lieu thereof by spraying lightly with water in fine mist. This moistening should not be overdone as very wet, overheated compacted tobacco bundles may turn to compost. All the green bundles should be placed in large wooden boxes with covers and placed on the floor of the flue-curing barn between flues and allow them to be re-cured with a new charge of fresh leaves. As the leaves have thoroughly dried previously

and do not need to be redried, the moment most of the bundles in the boxes are found to turn yellow, the boxes should be withdrawn from the barn, even before the high drying temperatures are reached.

Care of yellow tobacco.—As excessive moisture and heat may turn the yellow color to brown, by all odds these should be guarded against. Excessive moisture is the enemy of the yellow color of Virginia tobacco. Flue-cured tobacco attracts excessive moisture and with the sugar content of the leaves due to rapid artificial curing, Virginia tobacco is prone to be attacked by molds and fungi which will render them useless for the manufacture of cigarettes.

All of this fear of excessive moisture and moldiness is obviated if the tobacco is sold to a buying firm provided with a reconditioning plant.

While the tobacco is in the hands of the farmer, the following handling precautions should be observed:

1. He should never bundle too moist leaves. The practical test of the right moisture is to press the leaves with the hand and when the leaves return rapidly to original shape, without breakage, the moisture is about right. If the leaves remain compacted unduly after pressing, the leaves are too moist and should be allowed to dry up further before bundling.

2. If boxes or containers are available, the tobacco should be kept in these containers without undue pressing, or piled sufficiently high on covered wooden floor and covered with canvass, thick matting, etc. In other words, moisture should not be allowed to get into the yellow tobacco.

3. The pile or boxes of tobacco should not be allowed to heat or ferment.

4. When the weather is moist or when it rains, the tobacco should not be handled.

5. The tobacco should be sold as fast as possible, after curing.

6. The buyer should attend to the reconditioning, packing, and storage of the product for aging.

ILLUSTRATIONS

PLATE 1

The variety Cash, a sample of Virginia tobacco type.

TEXT FIGURE

Sketch of the flue-curing barn showing (A) the ground plan, (B) side view, and (C) end view and detail of ventilator. (Scale: $\frac{3}{8}'' = 1'$)

PLATE 1

The Philippine Journal of Agriculture

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AGRICULTURAL RESEARCH IN FORMOSA BEFORE 1945 [1]

By N. B. MENDIOLA [2]

ONE TEXT FIGURE

Brief history of agricultural research in Formosa.—Agricultural research must have been inaugurated in Taiwan almost simultaneously with the organization of the government of occupation for, according to Take-Koshi, as soon as peace and order was established after the occupation of the Island, a meeting of the governors from all districts was held and all the questions discussed concerned industries. One of these questions was about experimental farms. The meeting took place about the year 1902. In this year the Government of Formosa established its first experiment station in the same site where the present Agricultural Research Institute is located. This experiment station, besides doing research work, assumed the functions of an agricultural school and offered courses for students in agriculture especially Taiwanese. The station had

[1] A part of a report embodying the results of studies and observation made by the author in Formosa as a member of the Philippine Agricultural Survey Commission, during September, October, and November, 1944. Submitted for publication in 1945.

[2] Former director of research, College of Agriculture, University of the Philippines and superintendent of Agricultural Research, Department of Agriculture and Commerce. Presently, senior plant breeder, Bureau of Plant Industry.

to do it because at that time the government was not operating an educational system. The training given to students was very important and it contributed much to the agricultural development of the country. In 1919 the government established its regular educational system and the following year, 1920, the station was relieved of its educational work. Up to that time, it had trained some 900 students. In addition to the general agricultural experiment station, there had been established other stations for specific purposes. There were, for example, Sugar Cane Experiment Station, Horticulture Experiment Station, Tea Experiment Station, Animal Husbandry Experiment Station, and Forestry Experiment Station. In 1912 many of these experiment stations were amalgamated into a Central Experiment Station and became the Department of Agriculture of the Government Research Institute. The Institute had three other departments, namely, Forestry, Industry, and Hygiene. The Department of Agriculture had the following divisions: Agronomy, Agricultural Chemistry, Plant Pathology, Economic Entomology, and Animal Husbandry. It had the following branches: Horticultural Station at Shirin, Tea Experiment Station at Heichin, Kagi Experiment Station, Animal Husbandry Experiment Station at Koshum, Taito Experiment Station and the Sugar Laboratory at Takao. In 1936 the Tea Experiment Station at Gyochi was established as one of its branches.

On April 27, 1939, in accordance with the provision of Imperial Ordinance No. 275, the Department of Agriculture of the Government Research Institute became an independent entity whose function was to conduct experimental and research work in agriculture and was called the Government Agricultural Research Institute which name it bears up to this date.

Present status and organization of agricultural research in Taiwan.—Up to 1944 research and experimentation in agriculture and related fields are being conducted both by entities of the Government General and of the provincial and district governments.

Under the government-general, the most important entity is the Government Agricultural Research Institute with one branch in each of three provinces and one district and two branches in each of two provinces. Other agricultural research institutions supported by the Government General are the Faculty of Agriculture of the Taihoku Imperial University, the Government Sugar Experiment Station, the Cotton Research Institute, and the Horse Breeding Station all in Tainan Province,

the Forestry Experiment Station, and the Government Monopoly Bureau.

Research institutions supported by the provinces and districts are one provincial experiment station in each province and the District of Karenko. Fig. 1 is a sketch of the Island of Taiwan showing agricultural experiment stations and other agricultural research institutions in the various provinces and districts. This map shows that the entire Island is covered by a network of agricultural experiment stations and related institutes and is an eloquent proof of the very high importance which the Government of Taiwan attaches to agriculture and agricultural research.

The Government Agricultural Research Institute and its branches.—The most important government organization in Taiwan for agricultural research is the Government Agricultural Research Institute which is independent of the Bureau of Agriculture and Commerce and has a similar rank to that of a Bureau of our government. It has six technical and two administrative divisions. The technical divisions are Agronomy, Agricultural Chemistry, Phytopathology, Economic Zoology, Zootechnics, and Horticulture. The nontechnical divisions are the General Administration of the Farm and the Office of the Secretary.

The Institute is located in the outskirt of the City of Taihoku but its branches are scattered all over Formosa. The following are its branches: The Shirin Horticultural Experiment Station in Taihoku; the Heichin Tea Experiment Station in Shinchiku Province; the Gyochi Black Tea Experiment Station in Taichu Province; the Kagi Agricultural Experiment station and the Kagi Zootechnical Experiment Station in Kagi, Tainan Province; the Hozan Tropical Horticultural Experiment Station and the Koshun Zootechnical Experiment Station in Takao Province; and the Taito Tropical Agricultural Experiment Station in Taito District.

The appropriation of the Institute for 1944 including those of its branches amounted to 1,000,000 yen. For consolidating all research work in agriculture in Taiwan, attempt was made to secure for the same year an appropriation of two and one-half million yen.

Activities.—In 1941 the activities of the different Divisions in research, investigation, and experimentation were grouped as follows:

Division of Agronomy.

1. Varieties of agricultural crops
2. Methods of culture

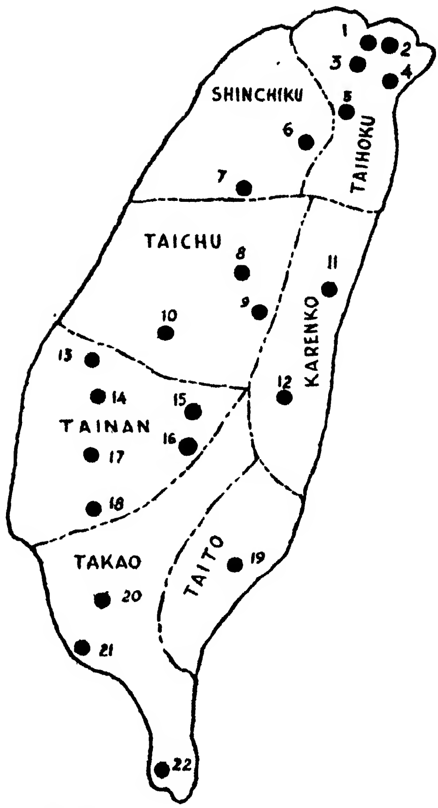

FIG. 1. Agricultural Experiment Stations in Formosa: 1, Shirin Horticulture Experiment Station; 2, Taihoku Imperial University; 3, Taihoku Provincial Experiment Station; 4, Government Agricultural Research Institute; 5, Taihoku Forestry Experiment Station; 6, Heichin Tea Experiment Station; 7, Shinchiku Provincial Experiment Station; 8, Soko Tobacco Experiment Station; 9, Gyoti Black Tea Experiment Station; 10, Taichu Provincial Station; 11, Kotobuchi Tobacco Sub-Station; 12, Karenko Provincial Experiment Station; 13, Cotton Institute; 14, Sugar Cane Experiment Station; 15, Kagi Agricultural Experiment Station; 16, Kagi Zootechnical Experiment Stations; 17, Horse Breeding Station; 18, Tainan Provincial Experiment Station (has two municipal branches); 19, Taito Tropical Agricultural Experiment Station; 20, Takao Provincial Experiment Station; 21, Kozan Tropical Agricultural Experiment Station; 22, Kosyun Zootechnical Experiment Station.

3. Agricultural implements
4. Agricultural meteorology

Division of Agricultural Chemistry.

1. Soils and fertilizers
2. Chemistry of farm crops and farm products
3. Preservation of agricultural products
4. Analysis and determination of matters related to agriculture

Division of Pathology and Entomology.

1. Plant diseases and useful fungi
2. Obnoxious and useful insects and harmful and useful animals
3. Control of plant diseases, obnoxious insects and harmful animals

Division of Livestock.

1. Rearing and improvement of livestock and fowls
2. Diseases of livestock and fowls
3. Processing of livestock products

Division of Horticulture.

1. Culture of horticultural crops
2. Improvement of varieties of horticultural crops
3. Processing of horticultural products

The Branch Agricultural Experiment Stations.—Of the ex periment stations of the Agricultural Research Institute, only four about which first-hand information could be obtained were visited by the Commission. These stations were those of Shirin, Gyochi, Kagi, and Hozan. Following are some of the notes made about these stations:

SHIRIN HORTICULTURAL EXPERIMENT STATION

(Established in 1908)

Area—42 hectares, 11 hectares, flat, rest hillsides.
Appropriation—30,000 yen
Personnel—6 members, as follows:
1 Director
4 Citrus specialists, and 1 other fruit specialist.

Its main activities are: 1. Work on temperate fruits; fruit research includes fruits both tropical and subtropical, banana, pineapple, citrus. Introduction and acclimatization. It is said progress in fruit culture in Formosa was due to the work of this station. The principal temperate fruits are kaki, pear, and grape. It has been conclusively determined that on the plains of Formosa, temperate fruits cannot be grown, so selection is being made among native varieties. Some 100 kinds of tropical fruits have been tried. Grapes from America are doing well in the northern part. Those from Europe are not doing so well.

2. Research with peanut, sweet potato and vegetable. This was started in 1944.

3. Propagation and distribution of planting materials of selected varieties. Already some 650,000 units for propagation have been distributed.

GYOCHI BLACK TEA EXPERIMENT STATION

(Established in 1934)

Location—850 meters above sea level.

Appropriation—25,000 yen, excluding salaries of personnel.

Activities.—Culture and manufacture of Assam tea. Among other things, studies on propagation of tea by cuttings are being conducted.

KAGI AGRICULTURAL EXPERIMENT STATION

This station was established in 1917, reorganized and expanded in 1920. At present there are plans for its further expansion.

This station had an area of 95 hectares devoted to the following crops: Cotton, 45 hectares; sweet potato, 25 hectares; fruits, 15 hectares; and rice, 10 hectares. It has 98 kinds of tropical fruit trees. Half of the area is devoted to general agricultural crops adopted to soil and climatic conditions of Southern Taiwan.

Personnel.—1 chief of station, and the following crop specialists.

1. Cotton section—2 seniors, 5 juniors
2. Sweet potato section—1 senior, 3 juniors
3. Rice section—1 senior, 2 juniors
4. Fruit section—1 senior, 4 juniors

Activities.—

1. Selection of sweet potato varieties.
2. Breeding of sweet potato varieties combining high tonnage of roots and high percentage of starch.
3. Trials of upland rice varieties for lowland cultures. Results of these trials are very satisfactory.
4. Breeding cotton for resistant to the larva of *Chlorita biggutula* Ishida. Some of the varieties produced are Taino 3, 4, 5, 6, 7, 8, 9 and 10. Taino 6 has been found better than Express.
5. Pineapple breeding. Six new varieties have been produced and selected. These are Taino 4, 5 and 6 recommended for table purposes and Taino 1, 2 and 3 for canning. A hybrid between smooth Cayenne and Native was served to the party.

In the early days of sweet potato work, the former superintendent was able to obtain 15 varieties from Taihoku Station but among these, those which were high yielders were low in

starch content and required more time in drying, while those rich in starch had low root yield. So further improvement work had to be done. As a result, there are now 30 varieties which are high yielders of root and possess high starch content. Such varieties are valuable in alcohol production. It was reported that some of the new varieties were produced by crossing native varieties which are good yielders but poor in starch content and American varieties which were rich in starch but poor root yielders. The names of some of the improved varieties are Taino 9 (the best), Taino 6, 27. All these are recommended for trial in the Philippines.

The average yield of sweet potato in Tainan is about 24 tons per Ha.

6. Operation of the Training Institute for farmers' sons.

HOZAN TROPICAL EXPERIMENT STATION

(Established in 1939)

Activities.—The activities of this station were divided into 4 sections (1) Pineapple, (2) Vegetable, (3) Pathology-Entomology, and (4) Utilization.

Accomplishments.—1. Preparation from pineapple of such products as citric acid, lactic acid, pineapple bran, sauce from the stem; preparation from banana, such as vinegar and powder.

2. Development of a method of producing onion seed and a method of producing bulb. For seed, the different steps in the work are: first, the seed is grown to produce bulb, then the bulb is grown to produce seed and then the seed is grown to produce bulb. For bulb, the seed is grown to produce bulb, the bulb to produce small bulbs, then the small bulbs are planted to produce large bulbs.

3. Treatment of radish seed for seed production. The seed is kept in a refrigerator for 15 to 20 days at from 4° to 8°C. before sowing.

4. Trial use of *Vicia faba* as food and as green manure crop.

5. Development of methods of culture of sweet potato for: (*a*) single crop planting, (*b*) intercropping with sugar cane and (*c*) planting after 2 crops of rice.

6. Development and selection of varieties of vegetables easily grown by farmers.

GOVERNMENT SUGAR EXPERIMENT STATION

Location—Tainan Province.

Appropriation for 1944—500,000 yen.

Divisions—Crop Breeding, Agronomy, Sugar Chemistry, Soils and Fertilizers, Phytopathology, Entomology, Fermenta-

tion Chemistry, Fiber Chemistry, and General Administration of Farm. A secretary's office handles routine administrative matters.

Activities and accomplishments.—1. Breeding of superior cane varieties. Some 30,000 seedlings are raised every year of which superior varieties are selected. The selected varieties are labeled F (Formosa) 1, 2, 3, etc. Some of the Formosa seedlings which have been selected are F 108, F 113, F 125 and F 133. F 133 has a high fiber content but is resistant to rot. It is a cross between P. O. J. 2725 and *Saccharum robustum.* F 113 is resistant to wind. Its stalks may bend but do not break.

2. Proved that deep plowing, even using cable plows, was beneficial. Trench method of culture has also been tried.

3. Proved advisability of heavy manuring.

4. Field use of hand refractometer for determining proper time of harvesting. For sampling juice for refractometer determination a combination cork borer and squeezer is used.

5. Importation of a toad that helped control cane pests. However this toad cannot survive the Formosa winter although it has survived in Hawaii and Porto Rico. It has poisonous gland.

6. Development of Koa method of sugar cane culture. The cane is planted before rice is harvested because the temperature is already too low for sugar cane after cane harvest.

7. Rate of application of fertilizers determined. In most parts of Formosa nitrogen deficiency is the most important factor to consider in fertilization. In some parts, it is potash deficiency. The best rates of N–P–K application per hectare are shown below.

Best	Next best	Worse	Third
35 kg. N. 20 kg. P. 40 kg. K.	35 kg. N. 20 kg. P. 20 kg. K.	35 kg. N. 20 kg. P. No K.	Control

8. Control of cane pests such as borers by utilization of natural enemies, like parasitic wasps and the heron and control of rats. One of these rats is a giant. Owls and trapping are used. Three kinds of trap are utilized. It was claimed that using the same traps made of bamboo and ramie twine some 250,000 rats had been caught in Bahay Pare in the Philippines during the occupation during a certain period of time.

9. Stimulation of growth of cane shoots by treatment with ash. By dipping the two ends of a cutting in ash, growth of the

shoots are stimulated. This treatment was discovered by a member of the staff and it is said it is now used widely. It was first applied as a method of disinfection. The ash used is either wood or grass but not coal.

10. Conversion of cane bagasse into industrial products like paper using magnesium sulfite as solvent, this chemical being available in Formosa.

11. Preparation of artificial charcoal from bagasse. The bagasse is burned to produce carbon, then mixed with clay, clay being 10 per cent. The fuel value is $\frac{3}{8}$ that of wood charcoal.

12. Preparation of animal feed out of bagasse. The bagasse is heated with $CaCO_2$ or with CaO, about 10 per cent, then heated for two hours, then dried in the sun, and then finally ground. The composition of the resulting product is as follows:

	Per cent
Water	8.59
Dry matter	91.41
Total	100.00
Moisture	8.59
Ash	0.84
Fiber	41.98
Protein	0.17
Fat	0.11
N-free extract	48.31
Total	100.00

The material could be used as human food.

13. Stimulation of shoot production by covering them with soil, hilling, then crushing by stepping on them.

14. Use of green manures:

Sesbania at the age of 45 days.

Crotalaria juncea at the age of 30 days.

Mucuna capitata.

Sugar cane has existed in Taiwan for more than 300 years. After Japan occupied the Island, large scale production was undertaken, especially under the rule of the Governor General and a former Director of the Bureau of Productive Industries. The latter proposed the abolition of private cane mills.

At the beginning the cane variety grown was one like the Rose Bamboo. It was a thick cane with high amount of sugar. But the cane variety was very weak, and susceptible to heavy winds. This variety was widely grown.

In 1912 a heavy typhoon which did very much damage to cane occurred. Red rot also spread very badly with the typhoon all over the island. These events led the country to adopt Java varieties—thin canes which can stand heavy winds though containing fair amount of sugar. But it was soon discovered that thick Java canes, the POJ, are much better than the thin canes, hence in 8 or 10 years, these thick canes replaced the thin. In 1920 they already occupied a large area and produced as follows:

	Per cent of production
2725 POJ	75.0
2878	17.3
2883	7.4
Total Java canes	99.7

POJ 2714 was also grown. It is interesting to note that POJ 2725 was not an important cane in Java.

The yield per hectare in Formosa is not very high, being statistically only 61.67 tons per hectare. But a good field may give from 90 to 100 tons per hectare.

The recovery percentage is very high. In 1936 it was the highest, 14.6 per cent, when compared with those of other countries as may be seen below:

Country	1914	1927	1930	1933	1936
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Cuba	11.00	11.23	12.39	11.56	......
Java	10.88	11.09	11.36	12.64	......
Formosa	10.28	10.30	12.76	13.5	(a)14

a Highest of all countries.

Formosan sugar technologists were all proud of this high recovery percentage. They explained the cause of it as follows:

As early as 1932 the stage of producing about 8,000,000 tons cane was reached. This production was considered too much and it was decided to decrease it; hence, in 1933 production was 5,250,000, and in 1934, 5,330,000 tons, to stabilize production. Acreage was decreased. To decrease, bottom and tops of cane were omitted in milling with the result that the percentage of recovery was raised. In 1935 production was increased to 8,090,000 tons.

The universal use of hand refractometer also caused high recovery. This was used in field examination of juice and in the determination of proper maturity of the cane. This hand refractometer was conceived by a manager in Formosa and manu-

factured by Zeiss Co. in Germany to which the idea concerning it was suggested. This instrument is already being manufactured in Japan at a very low price. It is also used in the examination of fruits.[3]

Another reason of high recovery is the early planting of cane. It was accidentally found that cane planted as early as June gives good recovery. The usual age of cane was 12 months—December to December. Now canes are usually 18 months old.

1940 Formosa area and production of sugar cane (Prof. Jose Velmonte's data)

	Area, Ko (0.97 Ha.)	Production, Kin (600 grams)
Taihoku	3,790.41	462,960,858
Shinchiku	12,067.47	1,047,718,998
Taichu	37,510.39	5,023,328,142
Tainan	76,717.85	10,300,794,666
Takao	27,442.35	3,628,523,281
Taito	2,710.06	237,636,243
Karenko	7,093.71	669,405,480
Total	167,332.24	21,370,367,668

GOVERNMENT COTTON INSTITUTE

Director—A man with 16 years experience in cotton research work.

Location—Tainan Province.

Area—About 20 hectares.

Appropriation—80,000 yen.

Personnel—Five men (3 agronomists, 1 entomologist, 1 chemist).

Equipment—Well equipped. Has a green house, screened for hybridization work.

Activities and accomplishments.—1. Introduction and acclimatization of cotton varieties. Some 400 varieties had been collected from different cotton-producing countries of the world, including China, Indo China, Burma, and the Philippines. Among long stappled cotton it was found that Sea Island was better than Pima Egyptian, because the latter produces in Formosa fibers only 1.2 to 1.3 inches long, whereas in the States its fibers are 1.5 inches long. Sea Island on the other hand produces in Formosa fiber 1.6 to 1.8 or even 2 inches long. The Sea Island stock came from St. Vincent Island.

2. The yield of cotton at the Institute is 4,000 kin of seed cotton per Ha. of Delfos variety. The method of growing

3 There are three types of hand refractometer. One reads from 0 to 30 per cent total solids. Another, from 30 tq 60 per cent and a third, from 50 to 80 per cent.

cotton, as for example intercropped with sugar cane, has been developed, the cotton being planted earlier. The development of the methods of cotton culture for Taiwan is as follows:

a. The season of planting is from end of May to July, the best time being from June to the first part of July.

b. No irrigation culture.

c. Green manure to be tried, to be planted March.

d. No fertilizer used except compost.

FORESTRY EXPERIMENT STATION

This station was established about 1911 as an Institute of the Bureau of Industries. About 1939 it became an independent institute and was named the Government Forestry Experimental Institute. It has branches in Tainan and Taito.

Area—3360 Ha. including branches, 17 Ha. in Taihoku City.

Appropriation—400,000 yen is total expenses.

Personnel—Eight technical men, 2 clerks, 13 assistant experts, about 100 nonregular employees.

Activities.—These are divided into divisions of Breeding, Management, Lumber, Forestry, Pulp, besides Research Laboratory for Southern Region, and Administration.

1. Study of some 1,000 species of forest plants, of which 200 are for lumber, 200 are indigenous, some came from Southern Regions. All species found all over the Island are represented.

2. The Institute has cinchona plantation in Taito. *Cinchona ledgeriana* has been found the most adapted to Formosa. The elevation found suitable for cinchona in southern part of Formosa is 700 meters.

3. *Acacia confusa* is an introduction into Formosa. Evidently it is a very successful forest plant as it is grown everywhere especially on hill sides. It is a good source of charcoal. Private people grow this species as well as cedar. The tannin extracted from *Acacia confusa* dyes clothes black.

4. Lumbang and other species of *Aleurites* such as *fordii* and *montana* are being tried in Taichu Province.

GOVERNMENT MONOPOLY BUREAU

Previously this Bureau had been conducting researches with salt, camphor, and tobacco. It has one Central Tobacco Experiment Station at Soko and two branch tobacco experiment stations, one for the eastern part of Taiwan located at Kotobuchi, and another for the southern part located at Kyokai. The Commission was informed that the researches under the Monopoly Bureau are being amalgamated.

One of the outstanding results of the experimental work on tobacco of the Monopoly Bureau was the successful production

of tobacco in Taiwan. Previously, Taiwan had been importing tobacco from the Southern Regions. In its desire to be self sufficient in this commodity, the country attempted to produce tobacco. At first there was doubt as to its success, but as a result of experiments, the culture was successfully introduced and the country became not only self sufficient but also an exporting country, the exports going mostly to Japan proper. Formosa's average yield of tobacco is two tons of dried leaves per Ha. Shortly after the outbreak of the present war, Formosa, finding much tobacco in stock, planned to export cigars and cigarettes to the Philippines, but on account of transportation difficulties, this plan could not very well be carried out. Because of the exigencies of war, the acreage of tobacco has been limited in favor of rice and other food crops. Wherever there is irrigation, rice and other food crops are grown instead of tobacco, this crop to be raised only on sandy and stony areas and on newly opened lands.

In the factory of the Bureau we were informed that experiments were being conducted to determine the possibility of using dust prepared from the bases and midribs of tobacco leaves as fertilizer. At present the dust is used as an insecticide.

TAIHOKU IMPERIAL UNIVERSITY

Research in the Faculty of Agriculture.—There are at least two faculties in the Taihoku University which are doing research work related to agriculture. These are the Faculties of Agriculture and of Science. In the commision's visit to the University it was shown the laboratories and conferred with the ranking members of the divisions of the Agriculture faculty. In general, it could be said that the researches conducted by the faculty of Agriculture are of fundamental importance to agriculture and, as may be expected, the results are not necessarily of immediate application in the farms but are calculated to advance the boundaries of sciences of agriculture.

An idea of the nature of this research work may be gained from the following brief notes which were made during our visit to the different laboratories.

In the Laboratory of Plant Physiology.—Our informant, a professor of Plant Physiology, showed us an experiment in progress in which an elaborate apparatus deviced by himself for recording stomatal movements was being used. The machine records the graph showing the variation in the opening of the stomata of different crop plants, much like a thermograph recording the temperature on chart paper. We are shown records of stomatal openings of such crops as rice and cucumber,

showing distinct differences between crops and variations among varieties under one species.

In the Bacteriology Laboratory.—This laboratory is maintaining stock cultures of more than 13,000 species and strains of bacteria which have been gathered from different regions like Hainan, Manchuoko, Southern Regions, and Japan proper. This collection is being utilized in the study of various uses of bacteria in agriculture. The bacteriologist informed us that he has found a bacterium which increases the yield of nodules of a certain green manure 6 or 7 times and, when this green manure is used in rice fields, it causes an increase in the yield of rice amounting to 60 per cent. Specific strains for soybean, for sesbania and for lupine have been isolated.

An interesting discovery mentioned to us is that of a bacterium which when applied to the root tips and root hairs of corn causes more vigorous growth. How this happens is not at present known.

In the Geology Division.—The Commission was received by a professor who was once a visiting scientist in the former Philippines Bureau of Science. He had been making some geology study of the Philippines and the visitors were shown what he called the latest geologic map of the Philippines.

In the Agricultural Chemistry Division.—The professor in charge of the Nutrition Laboratory received our party. In the conference that followed, the Commission learned that emphasis was being laid on research in vitamins B and C. One of the results of the work shows that soybean protein, especially in the preparation called "mizo", compares favorably with animal protein for purposes of human nutrition, although soybean is rather deficient in amino acid. While man can live to a certain degree on vegetable protein, the ideal condition would be for him to use also animal protein. To supply this protein where food containing animal protein cannot be easily obtained a preparation called cystine [4] derived from horn, hairs, and hoof of animals has been made. If this cystine is mixed with vegetable, its deficiency in animal protein is remedied in some way. This substance is fed at the rate of 0.1 gram per day to each laborer or each growing child. Cystine can now be produced in a laboratory but not yet on a commercial scale.

THE PROVINCIAL AGRICULTURAL EXPERIMENT STATIONS

There are six provincial agricultural experiment stations, one in each of the Provinces of Taihoku, Shinchiku, Taichu,

[4] Cystine is one of three amino acids of protein. The other two are tryptophane and tyrosine.

Tainan, and Takao and one in the district of Karenko. As the name implies, these stations are supported by provincial appropriations. The total appropriation for these stations for 1944 amounted to 500,000 yen, or an average of about 83,000 yen for each. The following brief notes will give an idea of the nature of the work and accomplishments of the provincial stations visited.

TAICHU PROVINCIAL AGRICULTURAL EXPERIMENT STATION

Area—15 hectares, flat land.

Appropriation—110,000 yen.

Personnel—One superintendent, 2 agronomists, 1 plant pathologist, 11 assistant experts (graduates in Agriculture), and many nonregular members.

Activities.—1. Rice culture methods on irrigated land, including rotation.

2. Rice breeding, for production of varieties resistant to rice blast, early maturing, those not sensitive to length of day and to temperature. Horai varieties being crossed with native varieties and with varieties of Southern Regions, something important in work on introducing varieties into Southern Regions.

3. Trial of wheat as catch crops between rice rows.

4. Search for early varieties of flax for use in rotations. If these are found, flax does not have to be grown as Koa [5] crop.

5. Study of best methods of sweet potato culture.

6. Study on the effects on rice crop of growing vegetables, sweet potato, sugar cane, and tobacco as catch crops. Each crop is supposed to affect the rice crop differently.

7. Cotton breeding for varieties resistant to pests specially and to diseases and for early maturity.

TAIHOKU PROVINCIAL EXPERIMENT STATION

Area—13 Ha. of which 7 Ha. are irrigated.

Appropriation—100,000 yen.

Personnel—Regular, 20; nonregular, 10; senior, 10; junior, 12.

Main work on rice and vegetables.

1. Varietal selection. Taihoku varieties are produced or isolated here. Selection work in rice for yield and for resistance to rice diseases, *Dactylaria grisea,* has been done actively in this station.

TAINAN PROVINCIAL EXPERIMENT STATION

Area—15 Ha. It has two branches, one at Kagi and another at Bokusi Municipality with a combined area of 10 Ha. The farms of the Central Station are unirrigated.

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[5] Koa is a special method of intercropping.

Activities.—Divided into four sections: (1) Breeding General Crops including operations of seed farms, (2) Industrial Crops, (3) Agricultural Chemistry, and (4) Plant Pests and Diseases.

The Kagi branch is devoting its time to studies on the culture of lowland and upland rices. The Bokusi branch is working on sweet potato.

The Breeding Section is working on general crops; the Industrial Crop Section is working on jute, peanut and sesamum. The Agricultural Chemistry Section as well as the Section of Pests and Diseases does work supporting the work of the first two sections.

The Central Station is experimenting with upland rice, peanut, sesamum, and jute in order to find the best methods of culture for unirrigated land not covered by Kanan Taishu irrigation system.

Accomplishments.—Varieties of rice suitable for different types of rice culture in the province have been produced. Among these varieties Kanan 2 and Kanan 8 are the most outstanding. One of these is a very high yielder, drought resistant, very resistant to pests and diseases, and now occupies more than 50 per cent of the Horai rice area in the province. A small area is occupied by Taichu 65 and some native varieties. The Kanan varieties are crosses between 183 and Taichu 65. Kanan 183 is a cross between Mii, a Japanese variety, and a certain glutinous native variety.

The types of rice culture for which the varieties are adapted are (1) one crop of rice in 3 years, the most important in the province; (2) two-crop culture (not so important); and (3) Koa culture on irrigated land. The area supplied only by rain water is negligible.

Relationship in agricultural research between the Agricultural Research Institute and the Faculty of Agriculture of the Taihoku Imperial University.—An intimate connection exists between the Agricultural Research Institute and the Faculty of Agriculture of the Taihoku Imperial University although they belong to two different branches of the Government General as a result of which many advantages have been secured and the research facilities of the government are utilized in the most economical way.

At present the Director of the Research Institute occupies a chair in the Faculty of Agriculture. Since a chair consists of one full professor, one assistant professor and two assistants, the Director through his staff in the Faculty plays an important

role in the higher agricultural education of the country. The director receives his salary from the Institute. He may be a candidate for Deanship of the Faculty of Agriculture although it is customary to elect as dean a full-time member of the professorial staff. The members of the Director's staff in the Faculty receive their salaries from the University. Members of the staff and advanced students of the faculty are permitted to carry on research work in and utilize the facilities of the Research Institute and under these circumstances become members of the Institute staff, although they do not receive any pay from the Institute. However, when traveling in the service of the Institute, they receive traveling expenses from the Institute.

While members of the University staff are free to choose their subject of research, the Director of the Institute could request some of them to do research work on certain specific subjects if he has no men in the Institute to do it.

In general there is a division of work between the University research men and those of the Institute, the first group usually confining themselves to what we call research in pure science while those of the second attend to the research in the applied field.

The Faculty of Agriculture has no experiment station of its own, but it has a small experimental farm. The desirability of amalgamating the Agricultural Research Institute, with the University was often discussed in the past but no definite conclusion has been reached except that while such amalgamation might be good for the University, it certainly would not be good for the Government General. The experimental farms of the Faculty of Agriculture might be enlarged but there was no intention of converting it into an experiment station.

When the results of research of a member of the Agriculture faculty turn out to be of applied value, they are turned over to the men of the Government General for extension purposes and the author of the results cooperate in extending the benefit of his work to the farms.

Relationships between experiment station of the Government General and those of the Provincial Government.—There is no formal organic relationship between the Agricultural Research Institute and its branches on the one side and the Provincial Agricultural experiment stations on the other. However, these cooperate and collaborate in their work. The subjects of research of the provincial experiment stations are decided by the

provincial governors. Sometimes the Government General subsidizes certain provincial research projects in which case the work is officially under the control of the Division of Agriculture of the Bureau of Agriculture and Commerce. It appears that there is a plan to place all the agricultural research institutions of Taiwan under the supervision of the Director of the Agricultural Research Institute. In fact, the Commission was informed that the provincial experiment stations of the Provinces of Takao and Taichu will soon be made branches of the Agricultural Research Institute. Another indication of this tendency is the organization in October of this year of all technical men in agriculture and related fields into one society headed by the Director of the Agricultural Research Institute.

The Mazuzama Tropical Plant Collection of Nisui.—The place was not in the Commission's itinerary but we happened to drop in it while waiting for train connection, the collection being almost adjacent to the grounds of the railroad station.

The collection is private, apparently serving as a commercial nursery. It is a large and rich collection. Practically all kinds of cultivated Philippine fruits and ornamentals are represented in it. We were informed that at one time more than 70 varieties of bananas were represented in its orchards.

The striking point about this nursery is that it is serving as an experimental trial ground for tropical fruit trees and ornamentals although operated as a private enterprise.

Emergency Society of all technical men of Formosa.—In order to mobilize fully the technical men of Taiwan, they have been recently organized into a society headed by the Director of the Government Agricultural Research Institute. All top technical men of Taiwan numbering 70 are members of the society, whether they are in or out of the government. The organization was completed on October 16, 1944 and consists of four sections; namely, (1) Farm Crops and Agricultural Machinery, (2) Technology, Sugar Centrals and Fertilizers, (3) Irrigation and Drainage, and (4) Animal Husbandry. Each section is headed by a chief, the first by Dean of the Faculty of Agriculture of Taihoku Imperial University; the second by a professor, the third by the Chief of the Irrigation Division; and the fourth by the Chief of the Animal Husbandry Division, all of the said University.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Agricultural Experiment Stations in Formosa.

COTTON IN THE PHILIPPINES

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INTRODUCTION

The word "cotton" refers to plants and the fibrous portion of the fruit of plants belonging to the genus *Gossypium,* family Malvaceae. It is known in the Philippines as *kapas* (Ilk.), *bulak* and *bulak na totoo* (Tag.), and *algodon* (Sp.).

Of the vegetable fibers woven into clothing, cotton is still the most important. Ramie [*Boehmeria nivea* (L.) Gaudich.], flax (*Linuan usitatissimum* Linn.), and hemp (*Cannabis sativa* Linn.), and abaca (*Musa textilis* Nee) contribute but a very insignificant portion. In the Philippines about 500,000 people depend for a good portion of their livelihood directly or indirectly on the cotton industry in which there is an estimated investment of 10,000,000 pesos.

Cotton cultivation and its conversion into some finished products were already established in India in 800 to 700 B.C. Its production gradually spread to Asia and Europe and finally to other parts of the globe. In the Philippines cotton was already grown in the Ilocos Provinces and Batangas Province before the Spanish regime. Prior to the Japanese occupation cotton was grown only on a limited scale to meet the meager demand of home industries except in the Koronadal Valley in Cotabato where commercial production was attempted under the auspices of the National Land Settlement Administration. In 1942 the Japanese government through subsidized cotton-growing companies tried an unprecedented large scale cotton production in the Philippines on 12,890 hectares in the Provinces of Pangasinan, Tarlac, Pampanga, Bulacan, Laguna, Cavite, Batangas and Bataan. However, this project, the goal of which was to plant 100,000 hectares to feed the cotton mills in Japan, failed. The failure of this venture was probably due to the choice of unsuitable regions, wrong varieties which were very susceptible to attack by leafhoppers, and the general apathy of the people.

In 1948 the area devoted to cotton production in the Philippines was 750 hectares as compared with 1,562 hectares in 1939. This decrease in cotton production might have been a contributory factor in the increase in the importation of cotton

goods. In 1939 the Philippines imported cotton and cotton goods valued at 39,314,510 pesos as compared with the tremendous amount of 137,363,424 pesos in 1948. Before the war, local cotton mills, the National Development Company, and the Philippine Cotton Mill imported annually not less than 5,000 bales[1] of raw cotton. With the speedy rehabilitation and expansion of the textile mills of the National Development Company which now consumes about 25 bales of raw cotton daily, the Philippines will have to import no less than 9,000 bales annually to keep these mills running. Moreover, our estimated yearly requirement of 200,000,000 yards of cotton clothing would necessitate either the importation or local production of about 125,000 bales of raw cotton.

SPECIES AND VARIETIES

Commercial cotton is derived from a number of species of plants. Two of these are grown exclusively in the Philippines. These are *Gossypium paniculatum* Blanco to which the Kapas Purao (Ilocos White) and Keute (Ilocos Brown) belong, and *G. punctatum* Blanco which includes the Batangas White. The Philippine tree cotton known in the Ilocos Provinces as "kapas kayo" and "kapas wagwag" is believed to belong to species *G. brasiliense* Macfad. *G. barbadense* L. is the source of special quality cotton like the Sea Island and Egyptian. Popular in China and India is *G. herbaceum* L. The upland cotton varieties of the United States belong to the species *G. hirsutum* L.

Commercially, however, cotton varieties are grouped according to the length of their staple. Cotton varieties with a staple length one inch and below are grouped as short staple; $1/32$ inches to $1^3/_{32}$ inches, medium staple; and $1\frac{1}{8}$ inches and longer, long staple. Chinese, Indian, and the American upland cottons belong to the short staple group. The local varieties, the Kapas Purao, Keute, and Batangas White, also belong to this group. The cotton grown in Brazil, Russia, West Africa, and Peru have medium staple. Belonging to the long staple group are the Egyptian, the Sudan, and the Sea Island cotton varieties.

In the field long staple cotton plants are distinguishable from those with short staple in that the former are generally taller than the latter. The stems and leaves of long staple cotton are glabrous, whereas those of short and medium staple cotton as having deep-lobed leaves and yellow flowers with purple are hairy. Long staple cotton plants are further characterized

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[1] One bale of raw cotton weighs 500 pounds.

as having deep-lobed leaves and yellow flowers with purple spots at the inner base of the petals. The leaves of short staple cotton are shallow-lobed and the flowers are creamy to white.

The long staple varieties have lint that is fine and silky which is suitable for adulterizing silk and wool. Their seeds are naked unlike those of short staple varieties which are covered with a coat of linters which are not removed during the first ginning process. This accounts for the fact that long staple cotton is easier to gin than short staple ones.

With a view to improving the quality of the local cotton produce, efforts were made to introduce long staple varieties in the Philippines. Of the varieties introduced by the College of Agriculture in Los Baños, Laguna, the Pima Egyptian was reported as found best. Trial plantings made by the Bureau of Plant Industry with Ashmouni and Sea Island showed that these long staple varieties do not yield normally under local conditions. Efforts were made however to hybridize these with the local variety Kapas Purao. Now, we have promising hybrids like Ashkarao 7 (Ashmouni × Kapas Purao), Kapland 15 and Puland 3 (Sea Island × Kapas Purao).

Tests conducted in Bataan on the native varieties showed that Kapas Purao gave an estimated yield of seed cotton per hectare of 950 kilograms; Batangas White, 750 kilograms; and Keute, 600 kilograms. Ferguson, an introduced short staple variety, with a computed yield of 1,000 kilograms of seed cotton per hectare, outyielded the local varieties in the same test.

A report on a two-year test conducted by the National Land Settlement Administration in Mindanao on several introduced cotton varieties revealed that Acala and Stoneville which gave respectively 1,000 and 950 kilograms of seed cotton per hectare were the best yielders. Of about 50 varieties introduced by the Japanese in 1942, Kanno, King's Improved, and Stoneville were rated as best while the rest were very susceptible to hoppers and to drought.

SOIL AND CLIMATE

The best soil for cotton is a well-drained sandy loam of medium fertility. Plants grown on barren soil yield a scant crop. On the other hand, those grown on very fertile soils have the tendency to overgrow vegetatively at the expense of boll formation. Alkali soils are not adapted to cotton if the salts

are permitted to accumulate at the surface root zone during the period of active growth.

Cotton requires a moist tropical climate. Occasional showers or light rainfall from germination up to the pre-blooming stage is beneficial for vegetable growth. However, excess moisture is conducive to more weeding expense and at the same time excessive woody growth of the plants at the expense of fruiting. A warm, dry weather is essential from the blooming stage up to the maturity of the crop. Rain during the blooming stage may prevent fertilization and cause the flowers to drop off. During the period of maturity, rain diminishes the quality of the product by causing discoloration and loss of luster of the lint and also prevents the normal opening of the bolls as they mature.

SEED SELECTION

Plants from which seeds for planting are to be obtained should be resistant to pests and diseases, prolific, true to type, and produce bolls that are large and uniform in size, persistent of attachment, and with a high percentage of lint. These plants should be selected in the field and properly tagged before the first picking. From these selected plants, only the seeds obtained from bolls born towards the center of the crown should be used for planting. Bolls at the base or at the tip of the crown oftentimes do not mature well and as such the seeds obtained therefrom lose their vitality easily. As soon as the gathered bolls are properly dried, the floss should be separated from the capsule, ginned, and the seeds selected. The seeds should be dried to constant weight before they are stored in air-tight containers.

CULTURE

Land preparation.—The land for cotton is generally prepared towards the end of the rainy season. In the Ilocos Provinces where planting is done in September to the early part of October, the land is prepared in August. After clearing, the land is plowed two or three times and harrowed after each plowing. The interval between each plowing is usually one or two weeks.

Planting.—As soon as the field is level and smooth, furrows are laid out 80 to 100 centimeters apart. For long staple varieties, the furrows should be spaced wider as these varieties

have the tendency to grow bigger than the short staple plants. The seeds are then sown 50 to 90 centimeters apart in the row. On clay loam soils, the hills are best distanced 50 to 75 centimeters apart; and on sandy loam soils of medium fertility, 70 to 90 centimeters. Spacing should be decreased on poor soils. In the United States close spacing and late thinning are advocated to induce an upright growth of plants so that the spaces between the rows remain open, thus leaving no obstacle for the convenient passage of machinery in cultivating and weeding, fertilizing, controlling pests and diseases, and harvesting. This practice results in the production of fewer bolls per plant but it is claimed that this is made up by greater number of plants accommodated per acre than when wider spacing is practiced.

In Laguna the best distance of planting as reported was 50 × 75 centimeters, and in the Koronadal Valley, 20 × 90 centimeters. In determining the distance of planting to be followed, the variety planted, the soil conditions and climate in the locality should be considered.

In sowing the seeds, it should be made a general rule that if a good supply is available, as many seeds as possible should be sown in each hill. A seedage rate of from 10 to 12 kilograms per hectare is sufficient for all practical purposes. Because of their oil content, cotton seeds lose their vitality easily. However, it will be much easier to thin than to replant. Besides, a uniform stand of plants is guaranteed.

In cotton cultures in the Lamao Experiment Station, Bataan, the practice was to sow at least 10 seeds to a hill. With a distance of planting of 70 × 90 centimeters, the plants were later thinned to three plants to a hill about two weeks after germination. It was also found advisable to soak the seeds overnight before sowing to facilitate germination and thus lessen the number of days of exposure of the seeds to the attack of insects while they are in their inactive stage.

Researches conducted in India showed that chemical treatment of cotton seeds increased the yield of seed cotton. Treatment with fungicides not only increased the yield but also destroyed fungus spores and insured better germination especially when conditions were unfavorable for quick germination. The chemicals used in this particular case were copper carbonate and sulfur.

Incidentally, the seeds are delinted with sulfuric acid solution to facilitate the mechanical planting in the field.

Indian researchers further revealed that cotton seeds delinted with a solution of zinc chloride dissolved in twice its weight of concentrated hydrochloric acid had a higher percentage of germination than either the untreated seeds or those soaked in water. Furthermore, treated seeds germinated earlier and the resulting plants were taller and accumulated greater dry matter than their controls.

Fertilizing.—Results of extensive experiments conducted in South Carolina showed that a proper proportion of nitrogen, phosphorus, and potassium was essential for the economical production of cotton. Phosphorus increased the yield and caused early maturity, while potassium apparently prolonged the productive fruiting period. In Virginia, these two elements were found to be of greater value than nitrogen which often caused losses when used in large quantities. Phosphorus was reported to be the most important element and is recommended for application even on fertile soils to obtain best results.

In Virginia, a 4–8–4 fertilizer mixture (4 per cent nitrogen, 8 per cent phosphoric acid, and 4 per cent potash) was found good and is recommended for application at the rate of 300 to 600 pounds per acre (336 to 672 kilograms per hectare) depending upon the fertility of the soil. In the College of Agriculture at Los Baños, Laguna, a 3–9–3 fertilizer mixture was found best applied at the rate of 400 kilograms per hectare.

When large amounts of fertilizer are applied, one half should be applied either broadcast in the furrows before planting or locally placed around the seeds during planting and the other half used as a top dressing after thinning. Experiments on fertilizer placement conducted throughout the cotton belt of the United States from 1930 to 1935 showed consistently that fertilizer applied at the time of planting gave the best results when placed in bands located on a zone 2½ to 3½ inches to each side and 1 to 3 inches below the level of the seeds. A study [2] performed in the College of Agriculture, Los Baños, Laguna, revealed that when the fertilizer was applied too close to the seeds, the seeds were injured and the final stand of plants was reduced. It was found that better results were obtained from applications 3 to 5 inches away from and at the same level with the seeds at planting time.

[2] Bartolome, Rafael O. The effect of placement of ammonium on germination, growth, and yield of cotton. Thesis presented for graduation, 1940, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, University of the Philippines. Unpublished.

Cultivation and weeding.—Cultivation should begin two or three weeks after the seeds have germinated. The first cultivation need not be deep but should be effective to destroy weeds. In other words, this cultivation is an off-barring operation; that is, the plow is passed in such a way that the furrow slice is directed away from the row of plants. When available, a cultivator may be used. The second cultivation may be done about a month later, before the plants flower. This should include hilling-up of the plants and made deeper than the first.

Irrigation.—When the plants appear to suffer from drought during the period of vegetative growth, they should be irrigated where irrigation is available. However, it should be born in mind that too much water is injurious to the cotton plants. In India experiments showed that the ginning percentage declined with heavier quantities of water.

Harvesting.—The harvesting season for cotton falls from February, where the crop is four or five months old after planting and lasts up to May generally. As soon as the bolls pop open, harvesting should not be delayed as the lint may be blown off to the ground and become dirty. Moreover, especially if the lint is wet with dew, the lint losses its luster and becomes discolored when exposed too long. Harvesting is done every three to seven days depending upon the rapidity of the bolls to pop open.

The common method of harvesting cotton in Northern Luzon is to pick the whole open bolls early in the morning when the bracts are not yet brittle. A disadvantage of harvesting entire bolls is that in the subsequent separation of the locks some bracts get mixed with the lint. Besides, the separation of the locks from the capsules which must be done preparatory to ginning affords another expense of time and labor. Moreover, it is not advisable to pick cotton when the floss is still damp with dew. To prevent dirt and other foreign matter to get mixed with the floss, a method recommended is to pick only the locks of the open bolls, leaving the bracts and capsules. This procedures requires the same time as when the whole open bolls are picked besides making harvesting practicable later in the day when the locks are already dry.

Intercropping.—The practice of intercropping cotton with corn is not an uncommon practice in the cotton regions of Ilocos Norte. Either all the rows or alternate rows of cotton are interplanted with corn. In this case, the distance of planting

between the hills of cotton is slightly increased to give way for the corn plants. It was observed in trips made by the junior author to that region that corn plants so interplanted gave good yields and was harvested in the latter part of December to the early part of January when the cotton plants began to bloom. On the other hand, it was also observed that in most cases, the intercropped cotton plants became slender and developed few fruiting branches. It was further observed, however, that in cases where cotton was planted on a commercial scale, no intercropping was practiced.

It may be stated in this connection that corn like cotton is a heavy consumer of soil nutrients. While the farmer gets the advantage of producing two kinds of crop on the same piece of land at the same time, it is very doubtful whether this advantage can make up for the rapid impoverishment of the soil as a concommittant of such practice. Researches have shown that a normal crop of cotton removes from a hectare of land 150 kilograms of nitrogen, 95 kilograms of phosphoric acid, and 160 kilograms of potash. Corn absorbs from the same area 105 kilograms of nitrogen, 52 kilograms of phosphoric acid, and 132 kilograms of potash. If it is necessary to grow cotton with some companion crops, farmers should not fail to fertilize the soil for obvious reason.

When intercropping has to be practiced, the use of nonclimbing leguminous crops like peanut (*Arachis hypogeae* L.), mungo (*Phaseolus aureus* L.), bush lima beans (*Phaseolus lunatus* L.) and soybeans (*Glycine max* L.) as a companion crop for corn to interplant with cotton will also give the advantage of producing two crops on the same piece of land at the same time. These crops mature earlier than cotton and like corn are harvested just as the cotton plants begin to bloom. Moreover, being able to feed on the nitrogen of the air, these legumes have the advantage over corn in that they do not compete with cotton for this element at a stage when its availability in the soil is most needed. Light feeders as they are, legumes do not cause as much strain on soil fertility as corn does.

Crop rotation.—Being only a five-month crop, cotton fits in conveniently in any crop rotation program. In the Ilocos Provinces, where the land used for cotton is upland, cotton is grown in rotation with other crops like corn, cowpea (*Vigna sinensis* L.), peanuts or other upland crops, corn being the most common. As cotton is a dry season crops, plants grown in rotation with it are raised during the rainy season. In Batangas, cotton is

grown generally after rice and corn. Cowpeas, mungo, and cadios [*Cajanus cajan* (L.) Merr.] are sometimes grown before cotton.

As stated elsewhere in this paper, cotton is a very exhaustive crop. For this reason, the inclusion of a legume in planning a crop rotation program should not be overlooked.

PESTS AND DISEASES

PESTS

Oriental cotton stainer.—There are two species of this insect pest, namely, *Dysdercus megalopygus* Bredd. and *Dysdercus poecilus* H. S., commonly called in the Tagalog regions as *bakabakahan.* Both the nymphs and adults puncture the immature bolls and the seeds with their proboscis. The punctured seeds exude a substance which indelibly stains the lint yellow. This pest can be controlled by collecting the adults and by brushing the nymphs which appear in colonies into a can containing some kerosene and by spraying with contact poison, such as soap solution with pyrethrum or nicotine sulphate.

Philippine boll weevil.—This pest, *Amorphoidea lata* Motsch., is one of the most injurious insects attacking the squares and bolls of cotton. The female punctures the young bolls and lays its eggs inside. Upon hatching, the grubs feed on young seeds and soft parts of the capsule. Attacked squares and bolls fall off resulting in a considerable decrease in yield.

Losses may be minimized by collecting and burning fallen squares and bolls. These still contain the larvae that fed on them. As the adult beetles have the habit of gathering in newly opened flowers in the morning, dusting with calcium arsenate mixed with an equal amount of starch (gawgaw) may also prove advantageous.

Cotton bollworm.—The cotton bollworm is the larva of a moth, *Heliothes obsoleta* Fabr. It feeds on the squares, flowers, and bolls of cotton. A pink bollworm, *Pectinophora gossypiella* Saund., was also reported destructive in La Union. These pests may be controlled by the destruction of old plants and fallen bolls after harvest. Larvae and egg masses should be destroyed and matured bolls should be harvested and fumigated with carbon bisulfide to kill the pest.

Leaf-eating worms.—The larvae of a number of species of moths feed on the leaves of cotton and cause considerable damage when abundant. The most important of these are the cotton semilooper or "Abutilon moth" (*Cosmophila erosa*

Hubn.), cotton pyralid leaf roller (*Sylepta derogata* Fabr.), tortricid leaf roller (*Homona* sp.), and cotton leaf miner [*Lithocolletis triarcha* (Meyrick)]. Dusting with calcium arsenate has been found effective to control most of these pests. The egg parasite, *Trichogramma minutum* Riley, which was introduced by the Bureau of Plant Industry, may be taken advantage of in cases of serious infestations by culturing the parasites and releasing them in the field.

Sucking insects.—A number of sucking insects attack the cotton plant causing not only mechanical injury but also loss of sap. It is also probable that these insects serve as vector for some kind of diseases. The most important of these sucking insects are the common mealy bug (*Ferrisia virgata* Cockerell), the melon aphis (*Aphis gossypii*), and the leafhopper (*Empoasca flavescens* Fabr.). In the cotton cultures of the Bureau of Plant Industry at the Lamao Experiment Station, Bataan, these sucking insects were effectively controlled with a spray of pyrethrum solution.

A more-detailed information on the pests of cotton appears in the Philippine Journal of Agriculture.[3]

DISEASES

Angular leaf spot.—This disease is caused by *Bacterium malvacearum* EFS, which attacks the leaves, stems, and branches and bolls of cotton. On the leaves, the disease manifests itself as water-soaked spots chiefly between the veins. At first the spots are translucent but later they turn brown. Coalescence of these spots resulting in a decrease in assimilating surface causes the leaves to turn yellow and to fall off early. On the green bolls, the disease appears as enlarging water-soaked areas. Small bolls fall off when infected, while the larger ones become first green spotted and then brown or black spotted and sunken in the attacked area. The lint below the spots does not develop or become wet, brown-stained and rotten. One-sided development of the bolls may also result. On the stems, the elongated water-soaked spots end in long sunken black stripes and the branch either shrivels or dies or breaks. From older lesions, there is often a bacterial ooze which dries up in the form of white granules, scales, or rusts.

The disease may be controlled by removing infected parts of plants and burning them. In serious cases a spray of Bordeaux mixture may be found advantageous.

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[3] Otanes, Faustino Q., and Filomeno L. Butac. Cotton pests in the Philippines. Phil. Jour. Agr. 10 (1939) 341–371.

Leaf blight.—The presence of this disease is manifested by circular, zonated and sometimes irregular brown spots on the margin of the leaves. These may coalesce and form larger spots. On the bolls, the disease appears as circular, slightly sunken dark-brown spots. Seriously infected plants become stunted and the bolls fall off. This disease is caused by *Helminthosporium gossypii* Tucker and can be controlled in the same way as angular leaf spot.

Anthracnose of cotton.—This disease is caused by *Glomerella gossypii* Edg. It attacks the bolls, stems and leaves of older plants and causes damping-off of seedling. It manifests itself as brownish sunken spots surrounded by a reddish border on the bolls. Since the fungus has been found to stay in the seeds, seed disinfection and seed selection from disease-free plants are recommended control measures. Spraying with Bordeaux mixture and collecting and burning infected parts and plants may also help eliminate the disease.

Sclerotium disease of cotton.—This disease is caused by *Sclerotium rolfsii* Sacc. and is considered identical with the Sclerotium disease of abaca, peanuts, soybean, and other plants. The disease attacks the stem at the ground level or just below it. The infected parts turn reddish brown, shrinks slightly, and finally rots and decays causing the death of the plant. Seedlings are more readily attacked than older ones. The disease can be controlled by burning infected plants and the soil around them. Plowing the sclerotial bodies under to about 10 to 15 centimeters deep will prevent the germination of the fungus.

Ginning of cotton.—Seed cotton for local consumption is generally ginned in a locally made cotton gin. This is especially true in Ilocos Provinces and some parts of Batangas where there are facilities for converting the filler into finished products.

COTTON GRADING AND CLASSIFICATION

There has not yet been any systematic classification of cotton in the Philippines. This is probably due to the fact that limited quantities are produced and that the production is largely used by the producers themselves. In the United States cotton is classified to determine its comparative value, to facilitate assorting of individual bales in lots of the same grade or staple length, and to expedite trading by affording the purchaser means of buying cotton on description without examination of actual samples.

Classification of cotton is based on grade, staple length, and character.

The elements of grade.—Grade denotes a composite of color, nature, and amount of foreign matter present in the lint and the preparation or ginning. Color is the first factor to be considered in determining the grade of cotton. The major divisions of color as applied to cotton classification are white, spotted, tinged, light stained, yellow stained, gray and blue stained.

The quantity of foreign matter is next considered in grading after color. The greater the foreign matter in the cotton sample, the lower is its grade. Foreign matter that may be found with the lint consists of leaf, shale, motes, sand and dust.

The preparation of the bale of cotton refers to the smoothness with which the lint is ginned. Poor ginning is evidenced by the presence of neps, gin-cuts in the staple, stringy cotton, or by a general appearance of roughness.

Staple length.—Staple length is more important in determining the value of cotton than grade. Long staple cotton commands a higher market price than short staple cotton. In fact, in the cotton market, premiums are allowed on cotton with more than an inch staple length. The official standard staple lengths in inches followed in the United States are below ¾, ¾, 13/16, ⅞, 15/16, 1, 1/32, and upward in like manner, in graduation of thirty seconds of an inch.

Character.—Character refers to the strength, body uniformity and smoothness of the fibers. Strength is one of the factors that determine the utility of a fiber. Body refers to the density of the fibers and their tendency to cling together while uniformity applies to the regularity of the length of fibers. Variation in staple length is mainly due to the growing of mixed varieties. Smoothness or silkiness of the fiber is a varietal characteristic which is desirable in cotton used in the manufacture of fine goods. Long staple cotton is endowed with this character.

Universal grades of cotton.—In the United States commercial cotton is graded on the basis of samples of the universal grades distributed by the Department of Agriculture. The Universal standard grades are as follows:

No. 1 or middling fair.—This is the highest grade of cotton. It has bright creamy to almost snow-white color. Very few bracts and leaves are mixed with the lint. This grade is

practically free from any kind of spot, stain and tinge and likewise free from dust.

No. 2 or strict good middling.—This is the second in the universal standard grades. It is creamy but not as bright as No. 1 or middling fair. The staple is practically free from neps and gin-cuts. It does not contain broken seeds. Broken pieces of bracts and leaves are more numerous in this grade than in No. 1 or middling fair.

No. 3 or good middling.—The lint contains few foreign material and a small amount of broken leaves and bracts. Gin-cut fiber and neps are practically absent.

No. 4 or strict middling.—This grade is creamy but not as lustrous as the preceding grades. The lint is practically free from gin-cut fibers, neps, shales, and other foreign materials but not as free as the preceding grades.

No. 5 or middling.—Known commercially as spot cotton, this grade is the basis of all the other grades. It contains a medium amount of large pieces of leaf and bracts and other foreign materials. The preparation is ordinary. It exhibits light attack of weevil and some traces of sand and dust.

No. 6 or strict low middling.—The staple is somewhat dull, approaching gray. Spots and tinge are exhibited by this grade. Considerable amount of dust and sand including motes, leaf, trash, and other impurities are found. Gin-cut fibers are numerous.

No. 7 or low middling.—Brightness is less pronounced in this grade than in No. 6 or strict low middling. This grade is dull approaching gray. Impurities are numerous. The preparation is fair.

No. 8 or strict good middling.—This grade is nearly the same as the lowest grade only that it has less impurities.

No. 9 or good ordinary.—This is the lowest among the universal grades. It has the most impurities, stains, spots, insect attacks and the poorest preparation. The fiber is dull and exhibits rough appearance.

System of grading.—The bales of cotton are first sorted according to their staple lengths. Their corresponding grades are then determined with the use of samples of the universal standard grades. Experienced graders usually can forego with the samples. The price of cotton then will depend first upon the staple length and second on the grade.

COST OF PRODUCTION

A. Cost of production per hectare of cotton [a]

Operation	Man-day [b]	Animal-day [b]	Total cost Pesos
Plowing, 2 times	6	6	24.00
Harrowing, 2 times	3	3	12.00
Furrowing	1	1	4.00
Planting	[c] 4	....	4.00
Seeds, 12 kilos at ₱0.30	....	....	3.60
Cultivation, 2 times	4	4	16.00
Fertilizer application	[c] 4	....	4.00
Cost of fertilizer, 300 kilos ammophos at ₱0.35	....	....	105.00
Harvesting (including picking of locks), 6 times	[c] 24	....	24.00
Total cost of production			196.60
Value of production, 500 kilos of seed cotton at ₱0.50			250.00
Net gain			53.40

[a] As secondary crop.
[b] At ₱2.00 a day.
[c] Women labor at ₱1.00 a day.

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JUTE INDUSTRY IN PAKISTAN AND NEW INDIA

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ONE PLATE

The Philippines was a heavy importer of jute bags and burlap from India long before and after the war. In 1948 our imports amounted to about 13,634,982 pesos. With the rapid rehabilitation of the sugar industry and present intensified campaign for the production of rice, corn, and beans, not to mention other crops which must be stored in sacks, the demand for this imported item is bound to increase. In view of this the Philippines long felt the need of a real jute industry and the establishment of jute factories.

The native jute grows wild in the provinces and the Bureau of Plant Industry has had successful cultures of this crop in the past. Lately, experimental jute farms have been established in the provinces and sample sacks have been produced in Manila but the processing was very slow as the sacks were made from nonstandard machines and the information obtained cannot be used as a basis for their manufacture on a large scale. Hence the need of a more definite information on the agricultural and industrial phases of the work.

With the idea of securing the foregoing information, the writer was sent to India and Pakistan on June 24, 1949, to study the jute industry in those countries it being presumed that since they are the main source of our imports, the jute industry must be highly developed there. The trip was authorized by a resolution of the Cabinet on March 16, 1948, but the study was made only from June 25 to August 5, 1949, owing to lack of fund.

Jute is the monopoly of Pakistan and New India. Of the world's consumption which averaged 11,020,000 bales and 7,700,000 bales in prewar and postwar years, respectively, 98

per cent comes from Pakistan and New India. The estimated world's consumption from 1933 to 1945 are as follows:

	Total consumption in bales of 400 pounds
1933–34	10,060,000
1934–35	10,034,000
1935–36	10,650,000
1936–37	12,610,000
1937–38	11,180,000
1938–39	11,050,000
1939–40	11,270,000
1940–41	7,900,000
1941–42	8,810,000
1942–43	8,880,000
1943–44	7,710,000
1944–45	7,760,000

The partition of Old India into New India and Pakistan effected on August 15, 1947, had a telling effect on jute and other allied industries in both countries. By virtue of this partition, Sind, Northwest Frontier Province, East Bengal, West Punjab, and Baluchistan of Old India went to Pakistan, and the rest of the continent to New India with the exception of Kashmir the status of which is still undecided. For purposes of levying customs duties, New India and Pakistan declared each other as a foreign country. For every pucca [1] bale exported to New India, an export duty of 9.30 pesos per bale or 2 centavos a pound is levied by the government of Pakistan. She also levies an export duty of 37.20 pesos per bale of raw cotton, 10 per cent ad valorem on raw hides and skins and 10 per cent ad valorem on cotton seeds, exported to the Indian Union. Similarly, for all jute goods, cotton cloth and yarn, oil seeds, vegetable oils, and manganese exported to Pakistan, the government of India has to pay duties. In line with this policy, for all jute manufactures sent to all parts of the world through Calcutta, the government of New India imposes an export duty of 49.60 pesos per ton on hessians and 37.20 pesos per ton on sackings. On the basis of existing world consumption of jute and on double duty in vogue, one by Pakistan on raw jute passing on land from East Bengal to West Bengal, and another by New India on jute goods and raw fiber exported through Calcutta to other countries, each country realizes from 18,600,000 pesos to 31,000,000 pesos from export duties. However, this practice results in the increase in price of jute which is borne by the consumers and in the production of jute substitutes in

[1] A bale weighing 400 pounds.

jute-consuming countries. Because of the excellent bargaining power of the jute associations and mill owners in Calcutta, a part of the duty collected is shifted to jute growers in Pakistan in the form of lower prices. Meanwhile, Pakistan has a plan afoot to put up jute mills in that country while New India is enlarging her jute areas to replace a considerable part of her imports of raw jute fiber from Pakistan.

PRODUCTION OF JUTE FIBER IN PAKISTAN

As stated in the foregoing paragraph, Pakistan produced about 6,200,000 bales of jute fiber in 1945–46, or about 80 per cent of the world's supply. Jute production in this country is concentrated in 16 districts in East Bengal. This place is naturally endowed with a good climate and soil and excellent natural retting facilities not available elsewhere in New India. East Bengal produces superior quality of fiber, strong and with excellent color suitable for the manufacture of hessians which accounts for about 47 per cent of the total jute manufactures in New India. About 70 per cent of the New Indian jute mill requirements come from East Bengal. Furthermore, about 45,000,000 people, or 64 per cent of the total population of Pakistan, live in East Bengal. About 90 per cent of these 45,000,000 people have a low standard of living, poor habitations, utilize the least amount of clothing, and need least comforts of life. This is probably one of the reasons why the cost of production of jute in this country remains low up to the present time.

On the New India side, jute is grown in Bihar, Orissa, and Assam and in regions around Calcutta. The area covered is insignificant compared with the area devoted to jute in East Bengal.

JUTE CULTURE

Jute is a money crop in both Pakistan and New India. In East Bengal, it is mostly grown on rice lands and rarely in highlands as is practiced in the Philippines. As the people derive more income from jute, they prefer growing this crop to rice. However, because of their licensing system, the government of Pakistan limits the production of jute to not more than one fourth of the individual land holdings and encourage the planting of rice in the remaining three-fourths to avert food shortage in that country.

Varieties.—About 75 per cent of the jute area in East Bengal and West Bengal is planted to *Corchorus capsularis*, a species

that withstands water-logging after attaining a height of one-half to one meter. The other 25 per cent of the acreage is planted to *Corchorus olitorius* which is adaptable to the highlands. In the Philippines, it is mostly the latter variety that is found growing which explains the fact that Philippine jute areas are located in the upland.

Seed selection.—The government of East Bengal maintains a seed nursery within the Dacca Agricultural Farm. There, they plant both species of jute, *C. capsularis* and *C. olitorius*, and make crosses or intensive selection of promising strains. D–154 (Dacca 154), a selection from *C. capsularis*, with a long vegetative period, tall, vigorous and late maturing was produced in this station. Fanduk (*C. capsularis*) is another common variety in East Bengal. This variety has a short vegetative growth, medium height, and early flowering habit. D–386 is still under test.

In West Bengal, India, there is maintained a sizeable area of good jute breeding plots within the Chinsurah Agricultural Farm, 24 miles from Calcutta proper. They have on trial improved Strain 040—753 (*C. olitorius*) and on propagation Chinsurah Green, which is the product of a 15-year selection test. They found Chinsurah Green not only highly resistant to water-logged condition but the best yielding variety.

Preparation of the land.—Primitive methods of preparing the land are still practiced; mechanized farming is unknown. The land is prepared with the use of native plows and harrows hitched to bullocks raised right on the farm. Land preparation consists in plowing followed by harrowing.

Planting.—The jute-planting season falls as early as the latter part of February to as late as mid-June. The seeds are broadcast by hand at the rate of 7 to 7½ kilos per hactare for the *capsularis* and 6 kilos per hectare for the *olitorius*. However, in the government experimental farms, the seeds are drilled in rows 15 inches apart and 6 inches between plants.

Fertilization.—No commercial fertilizers are used by the jute farmers. Cow dung is collected and broadcasted in the field before the preparation of the land. Some farmers use compost from decaying vegetable matter. Others fallow the land and practice crop rotation. Intercropping is not practiced. Some areas are naturally fertile because of regular deposits of silt when the rivers overflow their banks.

In the experimental farms, ammonium sulfate and superphosphate are used at the rate of 500 kilos and 320 kilos, re-

spectively, per hectare. When available, "Niciphos" is also used at the rate of 140 kilos per hectare. To correct soil acidity, lime is sometimes applied at the rate of 900 to 1,000 kilos per hectare.

Harvesting and retting.—Jute for fiber is never allowed to pod and is harvested in 2½ to 3 months after planting. However, a portion of the crop is allowed to produce seeds for planting in the next season. Jute for seed is harvested in about 4 to 5 months after planting. The Pakistan farmers are well versed in determining the critical period of harvesting for quality production of fiber.

Crops under water ranging from 4 to 5 feet deep are harvested and retted at ease. Harvesters with sickles dip under water, cut the stalks close to the ground, and bring them to the surface one bundle after another until long piles of stalks 3 to 5 feet wide, 5 to 10 inches thick, and about 30 to 40 feet long are floated on the water. The bundles of stalks are tied to pegs stuck to the ground and left to ret where they are. After 15 to 20 days the fibers are scraped off, washed, and dried in the sun or under shade.

In the highland regions cut stalks are piled in the sun standwise until the leaves are shed off in about three days. After that, they are carried to a nearby stream and soaked to ret.

Pests.—Some of the insect pests sometimes found in the jute field are hairy caterpillar, indigo caterpillar, red mites, aphis, thrips, jassids, grasshoppers, wireworms, mole crickets, white ants, and jute apion. The damages caused by these pests if they ever appear at all are insignificant with the exception of hairy caterpillar and jute apion which prove destructive in some particular cases.

Diseases.—*Rhizoctonia* disease has been found by the Indian Central Jute Committee to be causing damage at times on young seedlings. Chlorosis or the yellowing and wrinkling of the leaves are sometimes found on jute grown in paddy fields.

Control of pests and diseases.—The Government of East and West Bengal help the farmers in the control of pests and diseases. The general remedial measures undertaken by the government vary depending upon the kind of pests and diseases, degree and period of infestation, climatic conditions and other factors. The general methods employed in the con-

trol of diseases and pests consists of (1) bringing about conditions unfavorable for the development of the pests and diseases, (2) destruction of diseases and pests at a critical period preceded by a study of their life cycle, and (3) production of disease and pest-resistant plants as the case may be.

Marketing.—There are no cooperative marketing associations to handle the products of the poor farmers. The bundles of fibers in different sizes and weights are carried to nearby gowdown or warehouses where they are sold to middlemen or representatives of jute associations.

Baling.—The classification of the fiber begins when it arrives in the baling establishments located in big towns. There are 33 pucca and 2,021 kutcha presses scattered in the province of East Bengal. A pucca bale press is usually hydraulic which makes a compressed bale of 400 pounds. A kutcha press may be hand or power-driven which makes loose bales of about 300 to 325 pounds. Kutcha bales are intended for mills in New India while pucca bales are exported.

The official prices of loose jute and pucca bales as given in the May, 1949, issue of the Jute Bulletin are as follows:

Loose jute:

Classification	Price per pound (Pesos)
Jat White	0.31
District white	0.30
Jat tossa	0.33
District tossa	0.31

Pucca bales:

Classification	Per bale (Pesos)	Per pound (Pesos)
Dundee Crack Firsts	188.90	0.48
Mill Firsts	132.06	0.33
Narayanganj cuttings	77.50	0.19
Mill and tossa cuttings	76.88	0.19

Labor and seed requirement:

Dacca, East Pakistan:

Labor:	
181 man-days at Rs-1-8 (₱0.90) per man-day	162.00
60 woman-days at Rs-1-0 (₱0.60) per day	36.00
84 bullock-days at Rs-0-14 (₱0.50) per day	42.00
Materials:	
7.5 kilos of seeds at Rs-3-0 (₱.80) per kilo	13.50
Total	253.50

Bataan, Philippines:

Labor:	
56 man-days at ₱2.00 per day	112.00
155 woman-days at ₱1.00 per day	155.00
26 carabao-days at ₱1.00 per day	26.00
Materials:	
6 kilos of seeds at ₱1.50	9.00
Total	302.00

Economics of production:

East Pakistan (Commercial planting of C. capsularis)	
Yield per hectare, kilos	800
Value of production per hectare, 800 kilos at ₱0.46, pesos	368.00
Cost of production per hectare	253.00
Cost of production per kilo	0.31
Net income per hectare	115.00
Bataan, Philippines (Commercial planting of C. olitorius)	
Yield per hectare, kilos	750.00
Value of production per hectare, 750 kilos at ₱0.50, pesos	375.00
Cost of production per hectare	302.00
Cost of production per kilo	0.40
Net income per hectare	73.00

JUTE MILLS IN NEW INDIA

Although jute is claimed to be a native of Bengal, jute mills were not known in Old India before 1865. All fibers produced prior to this year must have been exported to feed the mills in other countries, most probably Dundee, which was the only seat of the jute industry for sometime. Then industrialists in Old India conceived the idea of establishing a jute mill along the bank of the Hoogly (Ganges) River, Calcutta, during that year. This was followed by the erection of a power-driven one in 1869, and in 1885, or 16 years later, there were already 9,700 power looms in operation. The consumption of fiber then went from 200,000 to 250,000 tons, or about 20 per cent of the total estimated production. As the number of looms increased to 38,379 at the beginning of the first world war, the consumption of jute fiber further went up to 700,000 tons, or about 50 per cent of the total crop. The number of looms continuously increased to 40,043 in 1918, 50,359 in 1924, and 66,705 in 1937. The growth of the industry gradually continued and when the partition of Old India into Pakistan and New India was effected on August 15, 1947, the latter had to her credit 71,000 looms, or all the looms of the undivided India.

PROCESSES IN NEW INDIA

New India has 113 jute mills concentrated in West Bengal. There are in that country 46,000 hessian and 25,000 sacking looms which constitute about 57 per cent of the total jute looms in the world. The mills consumed 6,393,000 bales of fiber in 1947 and 6,220,000 bales in 1948, or an annual average of 6,300,000 bales. As only about 1,700,000 bales, or about 25 per cent of the total mill consumption, are produced annually in New India, at least 4,600,000 bales, or 75 per cent of the annual consumption, have to be imported from Pakistan to keep the mills busy.

Jute goods in New India are either manufactured in the villages or made in jute mills which are located in and around Calcutta. The relative consumption of raw jutes by the New Indian mills and the village industries are shown hereunder:

Year	Mill consumption in India (Bales)	Consumption of raw jute in the villages (Bales)
1933–34	5,080,000	600,000
1934–35	5,410,000	600,000
1935–36	5,890,000	600,000
1936–37	7,070,000	600,000
1937–38	....	600,000
1938–39	6,560,000	600,000
1939–40	7,470,000	600,000
1940–41	5,940,000	600,000
1941–42	7,280,000	600,000
1942–43	7,100,000	600,000
1943–44	5,700,000	600,000
1944–45	6,000,000	600,000

The processes discussed in this paper refer to jute goods manufactured in jute mills on a commercial scale particularly hessians and bags now found in the market. The machinery mentioned hereunder are arranged in the order of their sequence of operation as found in commercial jute mills in New India.

Opening of bales and classification of the fiber.—As mentioned previously bales coming from the field are of two kinds, the "pucca" and "kutcha." The pucca bales are compressed by a hydraulic press and weigh 400 pounds each. These bales are usually exported. The kutcha bales are loosely pressed and weigh from 300 to 325 pounds. These are intended only for local manufacture.

Upon arrival at the mill, the bale strings are cut to open the bale. Then the fibers are classified.

Cutting of root ends.—From 6 to 8 inches of the butts are cut off by a simple device made up of steel blade 6 to 8 inches wide and 3 to 4 feet long attached to a wooden frame. All the root ends are separated and used for sacking wefts.

Softening.—The jute softeners commonly used in India are provided with batching apparatus. The batching fluid which usually consists of 20 per cent crude oil, 0.5 per cent soap, and 79.5 per cent water is premixed and fed into the baching tank attached to each softening machine. The object of batching is to lubricate the fiber and thus facilitate subsequent operations.

Carding.—From the softening machine, the fiber is passed through a breaker card to break up coarse fiber. The fiber comes out of this machine in the form of laps or rough slivers. The rough slivers are then fed into finisher cards where the fiber strands are thoroughly separated and then formed into finer laps.

Drawing or doubling.—The laps from the finisher card are fed into the first drawing frame. Four laps are drawn and formed into one. The laps or slivers are then fed into the second drawing frame whereby two laps are drawn and formed into only one. This process is intended to render the texture of the slivers uniform before they go to the roving frame.

Roving.—The principle in the roving frame is practically the same as in the drawing frame only that the slivers are further drawn, given a little twist, and wound in bobbins.

Spinning.—Jute yarns are spun when dry. In a regular mill one roving spindle can supply three sacking weft spinning spindles or nine 4″ × 4″ ordinary spinning spindles.

In the spinning of hessian warps and wefts, 3¾-inch, 4-inch, and 5-inch bobbins are commonly used to spin 7 to 8 oz. warp, 9 to 12 lb. and 16 to 24 lb. yarn, respectively.

Twisting.—Jute yarns are usually woven as single yarns. However, certain kinds of jute textiles require the use of two-ply and multiple-ply yarns. Single yarns from the spinning frame are therefore twisted together to the required number of ply to single yarns with the use of twisting machines. The twisted yarn is automatically wound into bobbins.

Winding.—With the use of winding machines, the yarn is wound from the spinning frame bobbins or from the twist frame

bobbins into cops with cop winders if used for weft and into cheeses with roll winders if used for warp.

Jute yarn intended to be bleached or dyed is reeled into hanks and bundled in the same way as linen. After the treatment, the yarn is wound in the same way as when they are taken out from spinning frame bobbins.

Dressing and warping.—Yarn from the cop winding machine now are dressed through the dressing machine where they are starched and automatically collected on a warp beam. The dressing machine may be single-ended, 3-cylinder or double-ended, 6 cylinder type, all measuring 52 inches wide. The tension of the thread is kept uniform by spring pressers. For spool winding, the speed of the thread guide is slow and for roll winding, the speed is faster to prevent unraveling of the ends.

Weaving.—Sacks and hessians were woven on specially devised looms for the purpose. Sacking looms have usually a reed space of 37 inches hessian looms, 52 inches or even wider.

Damping and calendering.—Before the cloth is passed through the 5-bowled calendering machine, 66 inches wide, it is first passed through a damping machine also about 66 inches wide. The function of the calendering machine is to flatten the yarn and to give the cloth a smooth finish.

Measuring and folding.—After the cloth is dampened and calendered, it is passed through the measuring and folding machine where it is automatically measured and folded.

Cutting.—From the measuring and folding machine, the cloth goes to the cutting machine, 47 inches wide where it is cut into desired lengths. As many as ten thickness of burlap can be cut by the machine in one operation.

Sewing.—From the cutting machine, the cloth goes to the sewing department. All machines are arranged in a series and each can sew from 500 to 700 sacks a day.

Printing.—The sack printing machine can print one or more colors in one operation. It is provided with a cylinder and covered with staves carrying the type needed.

Baling.—From the printing department, the sacks or hessians go to the baling press. A hydraulic baling press is provided with a pump to work the press. Each bale of sacks contain 400 pieces. The number of yards per bale varies.

USES OF JUTE FIBER

On account of its versatility, jute is very handy in local and world trade. The woven cloth is used as wrapping material in practically all cotton, jute, abaca, maguey, and ramie bales for export. The sacks made out of jute are universal containers for all conceivable articles ranging from bulb crops, rice, sorghum, millet, charcoal, etc., to cement. Other commercial uses of fiber are for the manufacture of carpets, rugs, door mats, tarpaulins, backings for linoleum, curtains, fish nets, and the like.

Jute fibers may be used for any of the foregoing articles of trade depending upon the preparation of the fiber, its quality and quantity, treatment and prices of the different grades.

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ILLUSTRATION

PLATE 1

FIG. 1. A field of *Corchorus capsularis* under water adjacent to rice field at Myminghsingh, Dacca, East Bengal.

2. Jute breeding plot. Chinsurah Agricultural Experiment Station, Calcutta, New India.

3. Front view of the spinning frame. Jute Technological Laboratory, Regent Park, Calcutta.

4. Back view of the spinning frame. Jute Technological Laboratory, Regent Park, Calcutta.

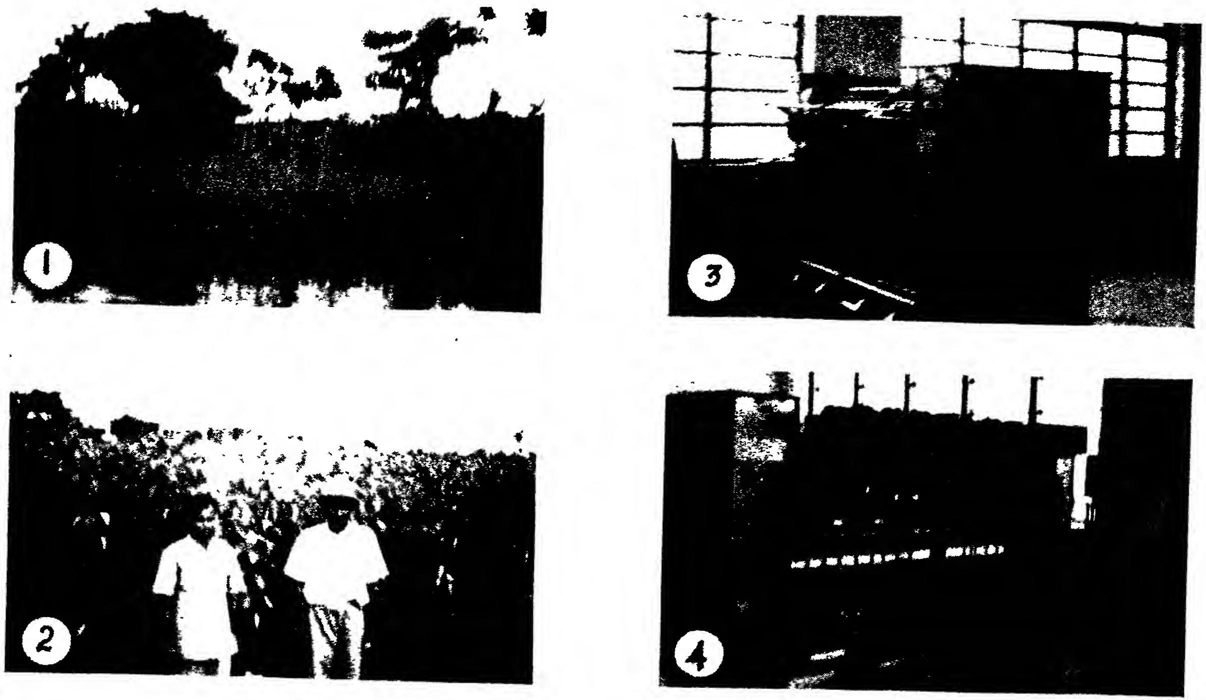

PLATE 1

A COMPARATIVE STUDY ON THE YIELDS OF LOCALLY PRODUCED AND IMPORTED SEEDS OF ONION

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INTRODUCTION

In a recent study(1) some onion varieties were induced to flower and to produce some seeds under local conditions by artificial wintering. Further trial tests(2) made in the provincial nursery of Ilocos Norte at Laoag showed that the Red Globe onion was found to flower and seed freely without any artificial treatment of the mother bulbs before planting. The seeds thus obtained when tested germinated and produced marketable bulbs. These observations indicate bright possibilities for improving the infant onion industry. Firstly, it shows the possibility of raising seeds locally for commercial planting, and secondly, it opens a new avenue for improving the varieties and strains locally grown through breeding and selection. Of course, there are other advantages that can be gained when the seeds are produced locally.

The present study was undertaken to answer one of the questions propounded when the present series of onion-seed-production studies was started, that is: Does the locally produced seeds give as much yield as the imported seeds? The study was conducted at the Ilocos Norte Provincial Nursery in Laoag, Ilocos Norte; at the Lamao Experiment Station, Limay, Bataan; and at the Central Experiment Station, Singalong, Manila. The different cultures were run from October, 1947 to April, 1948.

MATERIALS AND METHODS

Seed.—The seeds used in this study were: (1) the Red Globe onion produced in Laoag, Ilocos Norte, and will henceforth be called Laoag Red Globe in this paper; (2) the Red Globe onion imported from Calcutta, India, and will be called India Red Globe; and (3) the Yellow Bermuda onion imported from the Canary Islands. All the seeds were new and the percentage of germination was high.

Culture.—Three sets of separate cultures in different experiment stations, as has already been stated elsewhere, were run. The objectives of the cultures, the way they were run, and other matters, were the same.

In all the three stations the seeds were sown first in seedbeds and then transplanted about the end of December, 1947 to

early part of January, 1948 when the seedlings were about five to six weeks old. In all cases the seedlings of the three sets of onion seeds under comparative study in any one Station were uniform in age and the treatments given them were made as uniform as could possibly be done.

The soils of the experimental plots used in the Ilocos Norte Provincial Nursery and at the Lamao Experiment Station were of clay loam, and that at the Central Experiment Station was of sandy loam. The fields were thoroughly prepared with the use of plows and harrows and then put into plots of one meter wide and from 10 to 14 meters long, although the size and shape of plots used in one station were the same. A convenient path was provided between plots.

The plot was considered as the unit in this study and the replication was from 6 to 12. The plots planted to each kind of seedlings were picked at random. In each plot, three rows were established at 30 centimeters apart and the seedlings were planted in the rows at 10 centimeters apart. Only good and sturdy seedlings were used for transplanting. The seedlings used in the Manila culture were taken from the Ilocos Norte Provincial Nursery because the Central Experiment Station seedlings were badly damaged by the typhoon Jean which struck Manila on December 25–26, 1947. These seedlings have been pulled up from the seedbed three to four days before they were transplanted. They were, however, carefully packed and had never wilted.

The regular care necessary in the production of market onions was followed and given in as uniform a manner as possible to all plots in one station including the use of fertilizers as well as spraying, cultivation, irrigation, and weeding.

The crop was allowed to mature properly before harvesting. The harvest from each plot was made separate and the data needed were determined and recorded.

EXPERIMENTS AND RESULTS

This paper presents results of studies from October, 1947 to April, 1948 on the performance of the Laoag Red Globe as compared with the India Red Globe and the Yellow Bermuda. The data here presented were obtained from identical comparative cultures in three experiment stations.

Central Experiment Station culture.—The recovery of the seedlings was rather slow. This was perhaps due to the fact that the seedlings used here came from the Ilocos Norte Provincial Nursery and the planting was delayed for at least three to four days after the seedlings have been pulled up from the

seedbed. The plants also suffered from the attack of onion thrips which during the season was severe and could not be properly put under control with the use of DDT kerosene emulsion [1] due to irregular spraying because of poor facilities then obtaining. The plants also suffered from the effect of inadequate irrigation water. Hence, they did not develop well and as a result the bulbs as a rule were undersized. However, these conditions were more or less uniform on the different experimental plots and therefore the effect on the plants is believed not to have significantly altered the trend of the results thus obtained.

Table 1 presents a summary of the result of the Central Experiment Station culture.

TABLE 1.—*Comparative yields of Philippine-raised and imported seeds of of onion (Manila culture).*

Replication Number	Yellow Bermuda			Laoag Red Globe			India Red Globe		
	Marketable bulbs	Non-marketable bulbs	Total	Marketable bulbs	Non-marketable bulbs	Total	Marketable bulbs	Non-marketable bulbs	Total
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*
1	1.36	1.00	2.36	2.81	1.06	3.87	1.87	1.17	3.04
2	2.48	1.02	3.50	1.70	2.10	3.80	1.75	0.61	2.36
3	2.80	1.35	4.15	1.14	1.91	3.05	0.78	1.56	2.34
4	1.57	1.67	3 24	1.91	1.09	3.00	2.28	1.27	3.55
5	2.94	1.54	4.48	3.00	1.57	4.57	1.44	1.01	2.45
6	2.65	1.62	4.27	1.28	1.13	2.41	2.10	0.76	2.86
7	2.31	0.98	3.29	1.68	0.81	2.49	1.78	1.20	2.98
Mean	2.30 ±0.28	1.31 ±0.12	3.61 ±0.28	1.93 ±0.27	1.38 ±0.18	3.31 ±0.30	1.71 ±0.19	1.08 ±0.12	2.80 ±0.17

Lamao Experimental Station culture.—The seedlings developed normally and uniformly. Thrips were notice when the bulbs were already fairly well developed and while the attack was rather severe, the formation and maturity of the bulbs were little affected although they were somewhat undersized. Table 2 summarizes the results of the data obtained from this culture.

TABLE 2.—*Comparative yields of Philippine-raised and imported seeds of onion (Lamao culture).*

Replication Number	Yellow Bermuda			Laoag Red Globe			Indian Red Globe		
	Marketable bulbs	Non-marketable bulbs	Total	Marketable bulbs	Non-marketable bulbs	Total	Marketable bulbs	Non-marketable bulbs	Total
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*
1	7.48	1.22	8.70	5.14	1.21	6.35	5.23	0.94	6.17
2	10.42	1.16	11.58	9.32	0.75	10.07	4.96	0.86	5.82
3	8.14	0.80	8.94	7.84	0.91	8.75	7.48	0 73	8.21
4	8.62	0.71	9.33	7.34	0.72	8.06	4.14	1.03	5.17
5	8.48	0.65	9.13	9.31	0.24	9.55	1.10	0.71	1.81
6	6.38	0.72	7.10	5.81	0.52	6.34	6.95	0.44	7.39
Mean	8.25 ±0.55	0.88 ±0.10	9.13 ±0.59	7.46 ±0.71	0.73 ±0.13	8.19 ±0.65	4.98 ±0.93	0.79 ±0.09	5.76 ±0.91

Ilocos Norte Provincial Nursery culture.—The cultures had an excellent start. But as the plants were about to form bulbs, thrips began to attack them. A few days later the blight disease, *Macrosporium* sp. of onion became noticeable. The thrips were fairly well controlled by DDT–kerosene emulsion [1] sprayed at weekly intervals. The blight disease, however, due to the lack of good lime sulphur which, so far is considered the most effective fungicide for this disease, could not be controlled, and thus continued to cause damage to practically all the plants up to maturity. This, it is believed, was the main cause of the small size of the bulbs.

Unexpectedly, however, the plants from the Laoag Red Globe showed certain degree of resistance to blight disease. While their leaves were attacked by the disease, they remained noticeably erect and more normal than the leaves of the imported ones of both the India Red Globe and the Yellow Bermuda. It was noticeable that the plants developing from the imported seeds when attacked by the blight disease curled and dried up easily. Hence, the bulbs of the plants from the imported seeds, including the India Red Globe, were not able to develop as big as those of the plants from the seeds of the Laoag Red Globe.

Table 3 presents a summary of the results of the culture at the Ilocos Norte Provincial Nursery at Laoag. In this particular case the Laoag Red Globe seeds showed a decided superiority in yield over the India Red Globe and of the Yellow Bermuda seeds.

TABLE 3.—*Comparative performance of Philippine-raised and imported seeds of onion (Ilocos Norte Nursery culture).*

Characters studied	Laoag Red Globe [a] (local)	India Red Globe [a] (imported)	Yellow Bermuda (imported)
Number of seedlings planted per plot	180	180	180
Average number of bulbs harvested	156.0 ± 0.85	130.8 ± 0.86	103.0 ± 1.13
Average weight of bulbs per plot in lbs.	7.59 ± 0.088	3.10 ± 0.032	3.15 ± 0.041
Average weight of bulbs in grams	48.25 ± 0.675	23.25 ± 0.206	30.50 ± 0.373

[a] The same variety Laoag Red Globe has been locally produced while India Red Globe was imported from India.

DISCUSSION OF RESULTS

Since this was the first attempt to make comparative study of the performances in yield of locally produced onion seed

[1] The stock solution contains 4 liters of kerosene, 700 grams of DDT, 300 grams of soap, and 2 liters of water. One part of this stock solution is dissolved in 20 to 30 parts of water by volume before spraying.

(Laoag Red Globe) as compared with imported seeds (India Red Globe and Yellow Bermuda) it may be pertinent to discuss the results of the three cultures separately. This is necessary in order to make a better comparison of the three sets of seeds as they are grown under different soils as well as climatic conditions.

Central Experiment Station culture.—From the beginning, it was apparent that the development of the plants from the three sets of seeds was good, and practically no difference in growth was noticeable. In other words, the plants from the seeds produced locally (Laoag Red Globe) compared favorably in growth with those of India Red Globe and Yellow Bermuda, the two varieties that are presently grown commercially in the Philippines. Because of the still inadequate installation of water pipes at the time, the cultures did not receive sufficient irrigation water. For this reason, the plants did not produce as big bulbs as they should have done under normal condition. However, the effect on this particular point was practically the same in the different sets of seeds. It is seen in Table 1 that the Laoag Red Globe gave an average yield of 3.31 kilograms for every 14-square-meter plot, as compared with 2.8 kilograms for the same area in the case of the India Red Globe and 3.61 kilograms in the case of Yellow Bermuda. Apparently, Yellow Bermuda was the best in the above culture, but the Laoag Red Globe was decidedly better than the India Red Globe.

Lamao Experiment Station culture.—From the start, it was noticeable that the culture had a normal stand. But it was observed that the Laoag Red Globe and the Yellow Bermuda had a more vigorous growth and higher per cent stand than the India Red Globe. The corresponding average number of bulbs harvested for every 10-square-meter plot was 252, 233, and 256 for the Laoag Red Globe, India Red Globe, and Yellow Bermuda, respectively, and the corresponding average yield for every plot (Table 2) was 8.19 kilograms, 5.76 kilograms, and 9.13 kilograms. As in the Central Experiment Station culture the Yellow Bermuda was the best, followed by the Laoag Red Globe, and the India Red Globe was the poorest. The difference in yield between the Laoag Red Globe and the India Red Globe was significantly in favor of the former while that between the Laoag Red Globe and the Yellow Bermuda was only slight in favor of the latter.

Ilocos Norte Nursery culture.—As seen in Table 3, the performance of the three sets of seeds was different from their

performance at the Central Experiment Station and at the Lamao Experiment Station. The best in yield in this culture was the Laoag Red Globe, followed by the Yellow Bermuda, and the India Red Globe was the poorest. Laoag Red Globe gave an average yield of 7.59 kilograms to a 10-square-meter plot; Yellow Bermuda, 3,15 kilograms; and India Red Globe, 3.10 kilograms. In a statistical comparison of their yields, Laoag Red Globe was decidedly better than either the India Red Globe or the Yellow Bermuda. The superiority of the Laoag Red Globe was not only expressed in total yield but also in the stand of the crop and in the average size of the bulbs produced. Out of 180 plants set in a 10-square-meter plot, the Laoag Red Globe produced 156 bulbs as compared with the 131 bulbs of the India Red Globe and 103 bulbs of the Yellow Bermuda. As to average weight of bulbs, the Laoag Red Globe was decidedly better, giving an average of 48.25 grams per bulb as compared with the 28.25 grams of the India Red Globe and the 30.50 grams of the Yellow Bermuda.

The decidedly superior performance of the Laoag Red Globe as seen in Table 3 as compared with those of the India Red Globe and the Yellow Bermuda hinges on the fact that the Laoag Red Globe was found to be apparently more resistant to the attack of onion blight than the imported seeds. While the Laoag Red Globe was not entirely resistant to the attack of the onion blight, it nevertheless showed a comparatively high resistance to it resulting to its higher per cent stand and bigger bulbs.

It is significant to note that the Laoag Red Globe was performing well in three stations where it was tried. It was close second in yield to the Yellow Bermuda at the Central Experiment Station, but decidedly better than either the India Red Globe or the Yellow Bermuda at the Ilocos Norte Nursery in Laoag. It was at the Ilocos Norte Nursery, as already stated, that the Laoag Red Globe has shown a comparatively high resistance to the attack of onion blight. This, together with the fact that the locally produced seed (Laoag Red Globe) gave as much yield if not better than the imported Red Globe (India Red Globe) indicates far reaching significance in our present studies on onion-seed production. The results thus far obtained do not only show possibilities for commercial onion seed production here but they also indicate ways of improving the present varieties locally grown by breeding and selection for

better yield and quality, for resistance to pests and diseases as well as to better soil and climatic adaptability.

SUMMARY AND CONCLUSIONS

1. The data presented in this paper were obtained from trial tests in three different experiment stations of the Bureau of Plant Industry during the 1947–1948 onion season.

2. In the early development of the plants, there was no noticeable difference in their stand; this was particularly true in the case of the Laoag Red Globe and the India Red Globe. When the plants began to form bulbs, especially in the Ilocos Norte nursery culture, the Laoag Red Globe showed distinct superiority over the India Red Globe and the Yellow Bermuda.

3. At the Central Experiment Station, Manila, and in the Lamao Experiment Station, the Yellow Bermuda was the best in yield followed closely by the Laoag Red Globe; the India Red Globe was the poorest.

4. At the Ilocos Norte Nursery, the Laoag Red Globe was decidedly the best yielder. The Yellow Bermuda and the India Red Globe were about the same in yield, the former slightly better although not considered significant.

5. The Laoag Red Globe showed a high degree of resistance to the attack of onion blight to which both the India Red Globe and the Yellow Bermuda were very susceptible. The Laoag Red Globe bulbs had an average weight of 48.3 grams per bulb as against 30.5 grams of the Yellow Bermuda and 23.3 grams of the India Red Globe.

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STUDIES ON VARIETAL CROSSES OF UPLAND RICE

I. GENETIC BEHAVIOR OF CERTAIN CHARACTERS [1]

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FOUR PLATES

In the past, efforts at improving the yield of rice in the Philippines were concentrated mainly on lowland varieties so that practically little had been done to increase the low productivity per unit area of upland varieties, either by selection or by artificial hybridization.

It is a well-known fact that lowland as well as upland varieties have their own distinctive characteristics. They differ in the number of days of maturity, tillering capacity, density of grains in the panicle, yield, tendency to lodge, shattering quality, aroma and culinary characteristics of the grains, and resistance to drought, pests and diseases.

The prospect of developing an upland variety that possesses many if not all of the above-mentioned important agronomic characters and table quality desired both by producers and consumers through hybridization, can be seen in the commercial production of Raminad Str. 3, a hybrid lowland variety between Ramai and Inadhica. It may be pointed out, however, that our attempt to combine these valuable characters into one variety must be based on accurate knowledge of the mode of inheritance of individual characters of rice varieties. Such knowledge will facilitate and make more effective our improvement work by hybridization.

REVIEW OF LITERATURE AND PAST WORK

A number of studies on artificial hybridization of rice have been made in the Philippines.

Rodrigo (1925) artificially crossed Kariit and Kinamaleg in connection with his investigation on the pollination of rice. He reported that the hybrid seeds were deformed at the tip, but they germinated with high percentage in agar solution containing some nutrients.

[1] The data covering the results of the experiment up to the F_1 generation were presented before the seminar of the Bureau of Plant Industry on August 24, 1948.

[2] The author wishes to acknowledge the constructive suggestions of Dr. N. B. Mendiola, senior plant breeder, and of Director Felix D. Maramba, of the Bureau of Plant Industry, for his kind interest in the work.

Mulimbayan (1935), in her comparative study of two methods of emasculating rice flowers for artificial hybridization work, obtained with the clip method an average percentage of success of 32.69 and 29.61 in the long-grained and short-grained varieties, respectively, based on the grains that reached maturity. With the split method her average percentage of success was 30.78 in the long-grained and 25.56 in the short-grained varieties. She recommended the clip method of emasculation to get a higher percentage of formed seeds and the split method if the aim is to get a higher percentage of germination.

Capinpin and Punyasingh (1938), using lowland varieties in their study on varietal crosses and hybrid vigor in rice, obtained 21.16 per cent as the highest percentage of success on the basis of matured seeds. They concluded among other things that heterosis in the resulting progenies was marked in plant height, yield of grains, in panicle length; not marked in the number of culms, and no evidence of hybrid vigor in grain length and breadth, but grain thickness or shortest diameter of the grain showed little evidence of hybrid vigor.

Aragon (1938) produced the Elon-ram, a lowland variety of rice, from a cross between Elon-elon and Ramai performed in 1931. He reported that on the average, Elon-ram panicles contained 460 grains, about 200 grains more than the panicles of either Elon-elon or Ramai. He further reported that Elon-ram in its fifth generation produced an average yield of 107.9 cavans per hectare while Elon-elon and Ramai produced 67 and 79.7 cavans per hectare, respectively.

Torres crossed on December 4, 1928 two lowland varieties, Ramai and Inadhica, and produced Raminad Str. 3 which on the 4th generation proved to be not only pure and productive but also resistant to serious disease of rice, the stem rot disease.[3] At present Raminad Str. 3 is a widely grown commercial lowland variety.

In unpublished records Mercado[4] crossed artificially two upland varieties, Carreon and Tahud Ilahas, and produced Carti 42, a strain that is similar to Carreon in morphological characters and length of maturity.

[3] From the records of the Genetics Section and Committee on Plant Registration, National Research Council, whose Chairman in 1940 Dr. N. B. Mendiola generously consented to show to the author.

[4] Mr. Toribio Mercado was assistant instructor in Agronomy in the College of Agriculture, University of the Philippines, when he performed the cross.

The technique of emasculation generally used by the above-mentioned workers was the clip method which was done in the afternoon previous to the day of pollination or early in the morning before the spikelets begin to open their inner glumes. Pollen grains were gathered in a petri dish during dehiscence and with a camel's hairbrush pollinated the emasculated spikelets.

Among the foreign rice breeders, Jones of the United States produced the variety Calady in 1924 by crossing Caloro and Lady Wright. Ramiah (1927), (1933a), of India, and many other workers did hybridization of rice in connection with their studies on the genetics of this plant.

A relatively large number of studies on the inheritance of individual characters have been made by foreign investigators, Jones (1936). Very little studies, however, have been made on the inheritance of characters of Philippine rice varieties.

OBJECTS OF THE PRESENT EXPERIMENT

This paper is a report on the first part of the experiment on varietal crosses to improve the yield of upland rice through artificial hybridization of selected native varieties with the following objectives: (*a*) To study the genetics of some of the characters of upland rice hitherto unreported; (*b*) to combine the desirable qualities of Fortuna, one of the best-yielding varieties in the United States, with selected native varieties; and (*c*) to determine the best combination from different crosses for intensive selection.

TIME AND PLACE OF THE EXPERIMENT

The selection work on the native varieties and adaptability test of Fortuna under upland conditions used in this study, was started in November, 1943, while the different crosses were performed in 1946 at the Central Experiment Station, Manila. The work was continued at the Pangasinan Demonstration Station, Sta. Barbara, Pangasinan Province, from May, 1947 to December, 1948.

MATERIALS AND METHODS

IMPORTANT CHARACTERS OF THE VARIETIES USED

The important agronomic characteristics of the different varieties for which they were selected as parents are as follows:

Caawa II.—This is an early maturing variety which can be harvested in about 110 to 117 days after sowing. It is stocky in growth and tillers fairly well. It has plump well-filled grains that do not shatter readily. The eating quality is good.

Carti 42.—As has been mentioned in the review of literature and past work on artificial hybridization of rice, Carti 42 is a hybrid strain produced in the College of Agriculture, University of the Philippines. It has the same length of maturity as Carreon and produces profuse spreading tillers. Like Carreon, its grains are plump and well filled but tend to shatter readily when over ripe, and is good in eating quality.

Dinalaga.—It matures in about 131 days, is stocky in growth, and does not readily lodge at maturity. It yields fairly well and its dense grains in the panicle are slightly shattering. It has a very good culinary quality.

Fortuna.—While Fortuna is classified in the United States as a late-maturing lowland variety, it has been found to be adapted to upland conditions in the Philippines. Under upland culture, it matures as early as Dinalaga and Carreon. It has been found to be more resistant to drought than Carreon, Carti 42, and Pinablo, a widely grown upland variety in Pangasinan, and unlike these varieties Fortuna does not lodge readily even with strong winds at the time of maturity. It yields fairly well, is resistant to certain diseases, and is of good table quality.

Kinafe.—Kinafe is a glutinous aromatic variety that matures in about 120 days. It tillers fairly well with fairly stiff straw. Its grains are large and are nonshattering.

C45–2—This is an aromatic variety isolated in 1945 at the Central Experiment Station, Manila, and was mentioned as having a panicle variation in a previous paper by the author on "Notes on New Variation in Upland Rice."[5] It matures in about 124 days and yields fairly well. It is fair in tillering power, and has stiff straw with very dense grains in the panicle that are slightly shatterable.

C45–1.—Like C45–2, this variety was isolated in 1945. It matures in about 140 days. It has a fairly good tillering capacity with stiff straw and long panicle with long grains that have the tendency to shatter.

MINOR MORPHOLOGICAL CHARACTERS

The following table (Table 1) shows some of the minor morphological characters of the parent varieties used. As Fortuna is a common parent in each cross only the contrasted characters of the other parents in the combinations are indicated.

[5] Phil. Jour. Agr. 13 (1947) 99-107.

TABLE 1.—*Morphological characters of the parent varieties used.*

Characters	Parent varieties						
	Fortuna	Caawa II	Dinalaga	Kinafe	C45–2	Carti 42	C45–1
Color of base	Purple	Green	--------	Green	--------	Green	------
Nature of leaf-surface	Hairy	Smooth	Smooth	--------	Smooth	--------	Smooth
Color of stigma	Purple	White	White	White	--------	White	------
Color of empty glumes	Red	White	White	White	--------	White	------
Color of hull	Straw with purple tinge	Straw	Straw	Straw	--------	Straw	Brown
Color of apiculus	Purple	White	Slightly purple	Slightly purple	--------	White	------
Nature of hull	Hairy	Smooth	Smooth	--------	Smooth	--------	Smooth
Color of peduncle	Green	--------	Purple	--------	--------	--------	------
Character of kernel	Nonglutinous	--------	--------	Glutinous	--------	--------	------
Length of grain	Long	Short	Short	Large oblong	Medium	Short	------
Width of leaves	Broad	--------	--------	--------	--------	Narrow	------
Growth of tillers	Close	--------	--------	--------	--------	Spreading	------
Arrangement of rachilla.	Close	------	--------	--------	--------	Spreading.	------

TECHNIQUE OF HYBRIDIZATION

The following were the crosses made:

1. Caawa II × Fortuna.
2. Carti 42 × Fortuna.
3. Dinalaga × Fortuna.
4. Fortuna × Carti 42.
5. Kinafe × Fortuna.
6. C45–2 × Fortuna.
7. C45–1 × Fortuna.

In nearly all cases Fortuna was used as the male parent except in the reciprocal cross with Carti 42.

TECHNIQUE OF HYBRIDIZATION

Spikelets whose anthers were way up in the upper portion of the inner glumes and were expected to be ready for pollination in the next morning were emasculated either in the afternoon prior to pollination or early in the morning just before pollination. The florets were clipped off of their upper portion at an angle of about 45 degrees after which the anthers were carefully removed with a pair of fine forceps. Emasculation operation was done from the upper portion of the panicle downward to the lower spikelets in order to avoid the pollen grains from the upper spikelets dropping on the lower ones. The grains that were not emasculated were clipped off while the treated ones were bagged with a cellophane paper.

At pollination time, about 9:30 to 11:30 A.M., spikelets of the selected male plants that began to open their lemma and

palea were gathered. The anthers were carefully removed and their pollen grains poured into the emasculated florets. With this method it was possible to pollinate six or more emasculated grains with a single spikelet. After pollination, the spikelets were again bagged. The bag was not removed until the developed grains were matured.

The harvested hybrid seeds were dried in the sun for a few hours and then stored in air-tight vials.

GERMINATION OF THE HYBRID SEEDS

Mulimbayan (1935) and Capinpin and Punyasingh (1938) germinated F_1 hybrid seeds of rice in Crone's solution. The author, however, germinated emasculated seeds of Carti 42 $\times$ Fortuna and its reciprocal cross in washed sand for trial purposes on October 24 and November 7, 1946, respectively.

Having found that the use of washed sand was practicable, the author germinated on June 5, 1947, the remaining hybrid seeds of different crosses which were stored for 7 to 8 months in air-tight vials as follows:

The hybrid seeds of each cross were divided into two groups. In the first group they were soaked in water for 24 hours after which the water was drained off and the seeds incubated for another 24 hours. They were then sown in an ordinary garden soil without having been sterilized. In the other group the seeds were sown directly in germinating seed bed with ordinary unsterilized garden soil.

TRANSPLANTING AND CARE OF THE PLANTS

The seedlings from each cross were 17 days old when they were transplanted singly in an upland field adjacent to the plot planted to F_2 seeds of Carti 42 $\times$ Fortuna and its reciprocal cross that were harvested from the planting made in October and November, 1946. The seedlings were transplanted on June 23, 1947, at a distance of about 30 centimeters apart and the different crosses, 60 centimeters apart from each other.

In the second generation, seeds of individual progenies of different varietal crosses were planted singly in separate plots set at random. Each varietal cross was replicated two to four times depending upon the number of progenies obtained in F_1. The plants were distanced 40 centimeters between the rows and about 25 centimeters apart in the row. In the first generation the plants were cultivated once with the hoe while the F_2 generation was cultivated once with the plow without the moldboard, and occasional weeding was done whenever necessary.

METHOD OF STUDYING INHERITANCE IN F_2 GENERATION

The mode of inheritance and interrelations or association of some characters involved in the different crosses were studied in the field and in the laboratory. In the field, at flowering time, each plant was tagged, and the characters of some of its morphological parts, such as hairiness or glabrousness of the leaf and hull, color of peduncle and palea and lemma, were recorded. These characters were further studied in the laboratory.

In studying the character of the kernel of the seed of individual F_2 plants from the cross Kinafe × Fortuna in which glutinous and nonglutinous characters of the kernel were involved, twenty or more grains from each plant were hulled and the kernels examined as to their glutinous or nonglutinous nature. The plants whose kernels were opaque or chalky throughout were considered glutinous while those that had transluscent or shiny kernels were classified as nonglutinous. Those that possessed both types of kernel were called nonglutinous-glutinous plants.

RESULT AND DISCUSSION

1. PERCENTAGE OF SETTING OF ARTIFICIALLY POLLINATED FLORETS

Table 2 shows the results of artificial crossing of upland rice. As may be noted in the table, there was a wide variation in the percentage of setting of artificially pollinated florets. This may be attributed to four important factors, namely, the difference in the weather conditions at the time the spikelets were pollinated; the readiness or receptivity of the stigma of the florets emasculated as some may have been too young at pollination time; the difference in the number of grains pollinated in each cross; and the probable difference in the degree of compatibility between the parent varieties.

As presented in the table, as high as 70 per cent of the emasculated and artificially pollinated spikelets developed and reached maturity in the cross between Dinalaga and Fortuna, while the lowest, 20.8 per cent, was obtained from that of C45–1 × Fortuna.

TABLE 2.—*Results of crossing artificially different varieties of upland rice.*

Varietal crosses	Date of pollination	Spikelets pollinated	Date harvested	Developed grains harvested	
				Number	*Per cent*
Caawa II × Fortuna	Oct. 8, 1946	38	Oct. 25, 1946	13	34.2
Carti 42 × Fortuna	do.	40	Oct. 24, 1946	16	40.0
Fortuna × Carti 42	Oct. 2, 1946	41	do.	20	48.8
Dinalaga × Fortuna	Oct. 22, 1946	30	Nov. 12, 1946	21	70.0
Kinafe × Fortuna	Oct. 4, 1946	17	Oct. 24, 1946	7	41.2
C45-1 × Fortuna	Nov. 28, 1946	48	Dec. 23, 1946	10	20.8
C45-2 × Fortuna	Oct. 18, 1946	47	Nov. 8, 1946	12	21.5

2. PERCENTAGE OF GERMINATION

It will be noted in Table 3 that the percentage of germination of F_1 hybrid seeds soaked and allowed to incubate before sowing in the seed bed ranged from 66.6 to 100 per cent, while those that were sown directly in the seed bed had from 85.71 to 100 per cent with an average of 97.9 per cent. The high average percentages of germination obtained in the two methods used showed that artificial hybrid seeds from emasculated flowers may be germinated successfully directly in a germinating seed bed with unsterilized soil. The results further showed that such seeds of rice may keep their viability for eight or more months if stored in an air-tight container.

TABLE 3.—*Germination of F_1 hybrid seeds of upland rice.*

Varietal crosses	Soaked in water and allowed to germinate before sowing			Sown directly in the soil		
	Number	*Germinated*	*Per cent.*	*Number*	*Germinated*	*Per cent*
Caawa II × Fortuna	6	6	100.00	7	6	85.71
Carti 42 × Fortuna	4	4	100.00	4	4	100.00
Fortuna × Carti 42	6	6	100.00	6	6	100.00
Dinalaga × Fortuna	10	9	90.00	11	11	100.00
Kinafe × Fortuna	4	4	100.00	3	3	100.00
C45-1 × Fortuna	5	5	100.00	5	5	100.00
C45-2 × Fortuna	6	4	66 60	6	6	100.00
Average			93.8			97 9

3. BEHAVIOR OF CHARACTERS IN F_1 PLANTS

Very often emasculated florets are pollinated by their own pollen grains during the process of emasculation. To be able to determine whether the F_1 plants resulting from artificial pollination are hybrids or not, a breeder should know the dominant characters of rice in the F_1 generation. Such knowledge enables him to discard immediately in the F_1 generation plants that are not hybrids.

The results of the study on the behavior in the F_1 generation of contrasting characters involved in the different crosses under study are presented in Table 4.

a. Leaf characteristics.—In crosses involving green and purple leaf-sheath represented by Carti 42 × Fortuna, and Caawa II × Fortuna, the F_1 progenies of each cross had purple leaf-sheath, indicating the dominance of purple color over green and the hybridity of the plants since the mother variety had green leaf-sheath.

Varieties with smooth or glabrous leaf-blade on both surfaces like Caawa II, Dinalaga, C45-1 and C45-2 when crossed with

Fortuna whose leaf-blade surfaces are hairy, produced F_1 plants with hairy leaf-blade surfaces. Glabrousness of the leaf-blade is therefore recessive to that of hairiness.

The cross between Carti 42 × Fortuna in which the mother plant had narrow leaf-blade and Fortuna, broad leaf-blade, produced F_1 plants with broad leaves.

TABLE 4.—*Behavior of characters in F_1 plants of different varietal crosses of upland rice.*

Characters of rice involved in the cross	Crosses representing the characters	Dominant character in F_1 plant
a. Leaf characteristics:		
Green × purple leaf-sheath	Kinafe × Fortuna Carti 42 × Fortuna Caawa II × Fortuna	All purple leaf-sheath.
Glabrous × hairy leaf-blade	Caawa II × Fortuna Dinalaga × Fortuna C45-1 × Fortuna C45-2 × Fortuna	All hairy leaf-blade
Narrow × broad leaf-blade	Carti 42 × Fortuna	Broad leaf-blade
b. Nature of growth of tillers.		
Spreading × close	Carti 42 × Fortuna	Spreading.
c. Length of maturity:		
Early × late	Caawa II × Fortuna	More of earliness.
d. Characteristic of inflorescence.		
Purple × green peduncle	Dinalaga × Fortuna	Purple peduncle.
Spreading × close rachillae	Carti 42 × Fortuna	Spreading rachillae.
e. Grain:		
White × purple apiculus Green × purple stigma White × purple empty glumes	Carti 42 × Fortuna Caawa II × Fortuna	Purple apiculus, stigma, and empty glumes.
Straw × straw with slight purple tinge inner glumes	Carti 42 × Fortuna Caawa II × Fortuna Kinafe × Fortuna Dinalaga × Fortuna	Straw inner glumes. do do Dark purple inner glumes.
Glabrous × hairy inner glumes	Caawa II × Fortuna Dinalaga × Fortuna C45-1 × Fortuna C45-2 × Fortuna	All hairy inner glumes
Glutinous × nonglutinous	Kinafe × Fortuna	Seeds from the same plant segregated into nonglutinous and glutinous in approximately 3:1.
Short × long grain	Caawa II × Fortuna Carti 42 × Fortuna	Intermediate in shape and size.
Large oblong × long grain	Kinafe × Fortuna	Intermediate in size and shape.
Nonshattering × slightly shattering	Kinafe × Fortuna C45-2 × Fortuna	Nonshattering.

b. Growth of tillers.—As has been mentioned previously, Carti 42 produces a good number of tillers that spread distinctly. On the other hand Fortuna has few tillers that do not spread as distinctly as those of Carti 42. The F_1 plants from a cross between these varieties had very good tillering power, the tillers spreading like those of Carti 42. This seems to indicate that spreading characteristic of the tillers is dominant over nonspreading in the F_1 plants.

c. Length of maturity.—As may be seen in Table 5, when Caawa II, an early variety maturing in about 110 to 117 days

after sowing was crossed with Fortuna which matures in about 132 days, the resulting F_1 plants were early in maturity, requiring about 116 days after sowing in the seed bed. This is in conformity with the findings of Vander Stock in 1910, as cited by Ramiah (1933a), that earliness of the flowering age and consequently maturity was entirely almost dominant over lateness in F_1 plants.

TABLE 5.—*Days of maturity of different varietal crosses and some of the parent varieties.*

Varietal crosses and parent varieties	Date of sowing the seeds	Date of harvesting	Days of maturity
Caawa II × Fortuna	June 5, 1947	Sept. 29, 1947	116
Carti 42 × Fortuna	do	Oct. 19, 1947	136
Fortuna × Carti 42	do	do	136
Dinalaga × Fortuna	do	Oct. 4, 1947	121
Kinafe × Fortuna	do	Oct. 11, 1947	128
C45-1 × Fortuna	do	Nov. 5, 1947	153
C45-2 × Fortuna	do	Oct. 9, 1947	126
Carti 42	do	Oct. 19, 1947	136
Caawa II	do	Sept. 25, 1947	112
Fortuna	do	Oct. 17, 1947	134
C45-1	do	Oct. 29, 1947	146
C45-2	do	Oct. 9, 1947	126

d. Panicle characteristics.—The F_1 plants from the cross between Dinalaga and Fortuna involving purple and green peduncle of the panicle had purple peduncle extending to the inner epidermis. Like that of the purple color of leaf-sheath, the purple color of the peduncle was dominant over green.

In the crosses Carti 42 × Fortuna and Dinalaga × Fortuna in which spreading and nonspreading characters of the rachillae were involved, the F_1 plants produced panicles with spreading rachillae.

e. Grain characters.—When green and purple colors of stigma, apiculus, and empty glumes were involved as in the case of Carti 42 and Caawa II with that of Fortuna, purple was dominant in the F_1 plants.

In the crosses in which the color of inner glumes of the maternal plants was straw and that of the paternal variety, straw with slight purple tinge, as represented by Caawa II, Carti 42, Kinafe, and Dinalaga with that of Fortuna, it was observed that while the progenies of the first three combinations produce straw-colored inner glumes, those of Dinalaga × Fortuna had dark purple. This color was observed to fade slightly at maturity.

Between short and long-grained varieties as in the case of Caawa II and Carti 42 with that of Fortuna, the resulting F_1 plants produced grains that were intermediate in size and

shape between those of the parent varieties. Intermediate-sized grains were also obtained from the cross between Kinafe and Fortuna whose seeds are large oblong and slender, respectively.

Like in the leaf-blade, hairiness of the inner glumes was dominant over glabrousness as shown by the seeds of F_1 progenies from the crosses of Dinalaga, Caawa II, C45–1, C45–2 with that of Fortuna.

Nonshattering quality of the grain was observed to be dominant over shattering or slightly shattering as exhibited by F_1 plants from the crosses Kinafe × Fortuna and C45–2 × Fortuna.

In the cross Kinafe × Fortuna involving glutinous and nonglutinous character of the kernel, each of the three F_1 plants whose entire seeds were hulled separately produced nonglutinous and glutinous kernels in an approximate ratio of 3:1 as shown by the table below:

TABLE 6.—*Character and segregation ratio of kernels of F_1 plants from a cross involving glutinous and nonglutinous varieties.*

Plants	Character of Kernels: Number of nonglutinous	Character of Kernels: Number of glutinous	Ratio
1	456	182	2.85 : 1.14
2	884	254	3.11 : 0.89
3	740	230	3.05 : 0.95
Total	2,080	666	3.03 : 0 97

This finding is at variance with the uniform dark purple color of the inner glumes observed in F_1 plants from the cross between Dinalaga and Fortuna. This is also at variance with the common concept in plant breeding that in a cross between pure varieties segregation of the characters should occur in the F_2 generation. Segregation in F_1 plants is possible if one of the parents used was a hybrid in a heterozygous state. This is hardly the case in this experiment, however, because the parent plants have been under selection work since 1943 and the grains of all the six F_1 generation plants were exactly alike externally in size, shape, and coloration. The segregation of the kernels of the same plant in the F_1 generation into nonglutinous and glutinous seems to suggest the immediate influence of the genes controlling these characters upon each other.

4. COMPARATIVE PERFORMANCE OF F_1 PLANTS OF DIFFERENT VARIETAL COMBINATIONS

As Fortuna was a common parent in each cross a study of the performance of F_1 plants from the different combinations based on some agronomic characters such as height, tillering capacity, length of panicle, density of grains in the panicle, and yield may prove a valuable guide in the selection of a combination possessing desirable qualities, since all the dominant genes or characters from both parents had the chance to express themselves in the F_1 plants.

The results of the study are presented in Tables 7 to 11.

a. Height of the plants.—As may be seen in Table 7, F_1 plants from the different varietal combinations exhibited wide range of variation in average height. The crosses between C45–2, Dinalaga, and Caawa II with that of Fortuna were stocky in growth with average heights of 146.8, 147.3, and 147.5 centimeters, respectively. On the other hand, the resulting F_1 progenies from the crosses in which Kinafe, C45–1, and Carti 42 were involved were tall with average heights of 158.5, 193.0 and 192.5 centimeters, respectively (Plate 1).

TABLE 7.—*Comparative height in centimeters of different varietal crosses of upland rice in F_1 generation.*

Plant number	Caawa II × Fortuna	Dinalaga × Fortuna	Kinafe × Fortuna	C45–2 × Fortuna	Carti 42 × Fortuna	Fortuna × Carti 42	C45–1 × Fortuna	Total
1	145	136	138	127	189	165	177	
2	146	129	163	149	196	200	201	
3	145	143	168	164		187	183	
4	146	153	161	144		194	196	
5	147	156	160	150		197	195	
6	152	155	161			200	203	
7	141	145				204	196	
8	143	142				196		
9	152	151						
10	159	157						
11	147	148						
12		153						
Total	1,623	1,768	951	734	385	1,543	1,351	8,855
n	11	12	6	5	2	8	7	51
Mean	147.5	147.3	158.5	146.8	192.5	192.9	193.0	
SX^2	239,719	261,308	151,279	108,462	74,137	298,671	261,285	1,394,861

ANALYSIS OF VARIANCE OF HEIGHT OF DIFFERENT VARIETAL CROSSES OF UPLAND RICE VARIETIES

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Total	50	26,115.4		
Between varietal crosses mean	6	22,157.7	3,692.9	41.06**
Between plants of the same cross	44	3,957.7	89.94	

$$F = \frac{3{,}692.9}{89.94} = 41.06$$

F at 1 per cent level with 6 and 44 degrees of freedom = 3.24

$$\text{L. S. M. D.} = 2\sqrt{\frac{2(89.94)}{5.35}} = 11.6 \text{ cm.}$$

The analysis of variance for height showed that significant differences in this character existed among the different combinations. From this observation, it may be pointed out that as far as height is concerned, those crosses that are relatively short may be more desirable than the tall ones as the shorter combinations may not readily lodge at maturity.

b. Number of bearing culms.—The development of tillers of F_1 plants from different crosses transplanted under upland condition is presented in Table 8. Carti 42 × Fortuna had the highest average number of tillers, 17.5 per plant, which was significantly more than those of the other combinations except C54–1 × Fortuna. Fortuna × Carti 42 and C45–1 × Fortuna had also significantly higher average number of tillers than those of Kinafe × Fortuna, C45–2 × Fortuna, and Dinalaga × Fortuna. These two combinations, however, did not have a significant difference in number of tillers over Caawa II × Fortuna.

TABLE 8.—*Number of bearing culms of different varietal crosses of upland rice in F_1 generation.*

Plant number	Caawa II × Fortuna	Dinalaga × Fortuna	Kinafe × Fortuna	C45–2 × Fortuna	Carti 42 × Fortuna	Fortuna × Carti 42	C45–1 × Fortuna	Total
1	10	7	5	2	21	10	10	
2	13	5	9	7	14	20	15	
3	8	4	10	11		12	13	
4	11	8	9	5		11	20	
5	16	6	10	7		12	14	
6	21	10	9			11	12	
7	3	5				15	13	
8	7	7				12		
9	8	11						
10	9	15						
11	8	4						
12		8						
Total	114	90	52	32	35	103	97	523
n	11	12	6	5	2	8	7	5
Mean	10.4	7.5	8.7	6.4	17.5	12.9	13.8	
SX2	1,418	790	468	248	637	1,399	1,403	6,36

ANALYSIS OF VARIANCE OF THE AVERAGE NUMBER OF BEARING CULMS OF DIFFERENT CROSSES OF UPLAND RICE

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Total	50	999.7		
Between varietal crosses mean	6	431.4	71.9	5.56*
Between plants of the same cross	44	568.3	12.91	

c. Length of panicle.—As presented in Table 9, of the seven varietal combinations that of C45–1 × Fortuna had the shortest panicles, 27.3 centimeters. Fortuna × Carti 42, on the other hand, had the longest panicles, 32.4 centimeters. The

cross between C45–1 × Fortuna had significantly shorter panicles than the other varietal combinations except those of Dinalaga × Fortuna and C45–2 × Fortuna. Fortuna × Carti 42, on the other hand, had a significant difference in length of panicle over the other crosses except its reciprocal cross and Kinafe × Fortuna. Likewise Kinafe × Fortuna differed significantly in the average length of panicle over those of Caawa II × Fortuna, Dinalaga × Fortuna, and C45–2 × Fortuna (Plate 2). The last three crosses did not differ statistically in their average length of panicles.

TABLE 9.—*Average length in centimeters of panicle in different varietal crosses of upland rice in F_1 generation*

Plant number	Caawa II × Fortuna	Dinalaga × Fortuna	Kinafe × Fortuna	C45-2 × Fortuna	Carti 42 × Fortuna	Fortuna × Carti 42	C45-1 × Fortuna	Total
1	33.8	28.1	33.6	26.5	29.1	31.8	25.1	
2	29.0	23.3	33.4	29.5	31.5	32.9	26.3	
3	29.7	26.5	30.4	31.4		34.3	28.7	
4	26.6	29.1	30.5	28.5		32.5	29.3	
5	27.8	30.3	33.5	29.5		30.5	25.6	
6	27.4	28.8	31.6			31.6	29.0	
7	31.5	29.8				32.3	26.8	
8	30.8	27.9				33.6		
9	31.9	28.1						
10	29.0	31.6						
11	26.5	30.5						
12		32.1						
Total	324.0	346.1	193.0	145.4	60.6	259.5	190.8	1,519.4
n	11	12	6	5	2	8	7	51
Mean	29.5	28.8	32.2	29.1	30.3	32.4	27.3	
SX^2	9,598.44	10,044.37	6,219.74	4,240.96	1,889.06	8,427.45	5,218.48	45,588.50

ANALYSIS OF VARIANCE OF THE AVERAGE LENGTH OF PANICLE IN DIFFERENT VARIETAL CROSSES OF UPLAND RICE

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Total	50	322.30		
Between varietal crosses mean	6	149.94	24.99	6.4**
Between plants of the same cross	44	172.36	3.92	

L.S.M.D. = 2.4 cm.

d. Number of grains per panicle.—Table 10 shows that the combination C45–2 × Fortuna had the greatest number of grains, 309.8 per panicle. That of Caawa II × Fortuna had the lowest, 208.5 grains per panicle.

The cross C45–2 × Fortuna had a significant difference in number of grains per panicle over the other varietal crosses except Carti 42 × Fortuna and its reciprocal cross. Similarly the differences in mean number of grains of Fortuna × Carti 42 and its reciprocal cross over the other varietal com-

binations except Dinalaga × Fortuna were significant. The other crosses had insignificant differences in average number of grains per panicle.

TABLE 10.—*Average number of grains per panicle of different varietal crosses of upland rice in F_1 generation*

Plant number	Caawa II × Fortuna	Dinalaga × Fortuna	Kinafe × Fortuna	C45-2 Fortuna
1	276.6	247.1	206.0	233.0
2	223.6	189.2	222.7	250.7
3	214.5	231.5	207.5	322.3
4	189.4	276.5	217.8	359.2
5	164.2	299.6	240.2	383.8
6	173.5	272.0	223.1	
7	243.0	242.8		
8	222.3	251.4		
9	266.1	246.8		
10	195.5	268.4		
11	174.3	255.3		
12		337.5		
Total	2,293.0	3,118.1	1,317.3	1,549.0
n	11	12	6	5
Mean	208.5	259.8	219.6	309.8
SX ²	496,887.26	824,830.65	289,994.03	497,343.86

Plant number	Carti 42 × Fortuna	Fortuna × Carti 42	C45-1 × Fortuna	Total
1	226.6	294.0	161.6	
2	324.1	290.1	203.9	
3		301.6	249.3	
4		295.6	260.6	
5		234.5	190.5	
6		247.6	243.0	
7		304.8	254.2	
8		297.4		
9				
10				
11				
12				
Total	550.7	2,265.6	1 563.1	12,656.8
n	2	8	7	51
Mean	275.4	283.2	223.3	
SX ²	156,388.37	646,581.74	357,709.51	3,269 735.42

ANALYSIS OF VARIANCE OF THE AVERAGE NUMBER OF GRAINS PER PANICLE OF DIFFERENT VARIETAL CROSSES OF UPLAND RICE

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Total	50	128,665.11		
Between varietal crosses mean	6	58,525.69	9,754.28	6.12**
Between plants of the same cross	44	70,139.42	1,594 08	

L.S.M.D. = 48.82 grains

e. Yield per plant.—It could be seen in Table 11 that Fortuna × Carti 42 and its reciprocal cross had the highest mean yield of 70.6 and 66.0 grams per plant, respectively. The

mean yield of Fortuna × Carti 42 was significantly greater than the mean yields of the other varietal crosses while that of its reciprocal cross was greater statistically over the other combinations with the exception of Kinafe × Fortuna. On the other hand, C45–1 × Fortuna produced the least, 29.4 grams per plant. This mean yield, however, was not significantly lower than those of the four other combinations.

The significant differences in all cases of the important agronomic characters exhibited by F_1 plants from different crosses seem to show not only possible differences in hybrid vigor of different combinations in which Fortuna was used as a common parent but also the possibility of knowing in the first generation probable good combinations based on certain desired agronomic qualities.

TABLE 11.—*Comparative yield in grams per plant of different crosses in the F_1 generation.*

Plant number	Caawa II × Fortuna	Dinalaga × Fortuna	Kinafe × Fortuna	C45-2 × Fortuna	Carti 42 × Fortuna	Fortuna × Carti 42	C45–1 × Fortuna	Total
1	39.0	37.0	26.0	7.0	54.0	49.0	2.0	
2	60.0	18.0	47.0	35.0	78.0	99.0	2.0	
3	24.0	10.0	55.0	36.0		71.0	25.0	
4	37.0	42.0	37.0	71.0		66.0	34.0	
5	61.0	31.0	64.0	52.0		56.0	57.0	
6	68.0	62.0	50.0			68.0	40.0	
7	18.0	25.0				86.0	46.0	
8	35.0	33.0				70.0		
9	35.0	67.0						
10	42.0	84.0						
11	27.0	14.0						
12		60.0						
Total	446.0	483.0	279.0	201.0	132.0	565.0	206.0	2,312
n	11	12	6	5	2	8	7	51
Mean	40.5	40.3	46.5	40.2	66.0	70.6	29.4	
SX^2	20,678	25,417	13,875	10,315	9,000	41,655	8,754	129,694

ANALYSIS OF VARIANCE OF THE YIELD PER PLANT OF DIFFERENT CROSSES IN F_1 GENERATION

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Total	50	24,883.33		
Between varietal crosses mean	6	8,444.46	1,407.41	3.7*
Between plants of the same cross	44	16,438.87	373.61	

5. NATURAL INFECTION OF LEAF-GALL DISEASE OF RICE ON F_1 PLANTS AND THEIR PARENT VARIETIES

While gathering the data on the number of tillers of the different F_1 hybrid plants, the author observed that some leaves of some of the plants were dark green and deformed.

Close examination of the leaves showed that on their under surfaces, elongated protrusions or galls that were rough to the touch were present. The malady was identified later by Mr. Julian A. Agati, Assistant Plant Pathologist, Bureau of Plant Industry, as the leaf-gall disease of rice caused by a virus.

Counts of the affected hybrid plants were made on July 23, 1947 and August 20, 1947. The data on the infection of the disease on different varietal combinations and their parents that were planted in adjacent plots are presented in Table 12.

TABLE 12.—*Natural infection of leaf-gall disease of rice on F_1 hybrid plants and their parents.*

Parent varieties and their combinations	Total number of plants	No. of plants infected on July 23, 1947	Percentage of infection	No. of plants infected on Aug. 20. 1947	Percentage of infection
Carti 42 × Fortuna	2	2	100.00	2	100.00
Caawa II × Fortuna	11	1	9.09	0	9.09
Dinalaga × Fortuna	12	0	0	0	0
Kinafe × Fortuna	6	0	0	0	0
Fortuna × Carti 42	8	8	100.0	8	100.0
C45-2 × Fortuna	5	0	0	0	0
C45-1 × Fortuna	7	5	71 4	6	85.7
Carti 42	62			18	29.03
Dinalaga	54			0	0
Kinafe	61			0	0
Caawa II	59			0	0
Fortuna	59			2	3.39
C45-2	59			0	0
C45-1	54			13	24.07

Examination of the table shows that not all of the parent varieties and their combinations were affected, and as high as 100 per cent infection was observed in Carti 42 × Fortuna and its reciprocal cross. Other combinations that were badly infected were C45-1 × Fortuna and Caawa II × Fortuna, with 85.7 per cent and 9.09 per cent infection, respectively. On the other hand, combinations Dinalaga × Fortuna, Kinafe × Fortuna, and C45-2 × Fortuna did not show any sign or symptom of the disease.

Of the parent varieties Carti 42, C45-1, and Fortuna had 29.03, 24.07, and 3.39 per cent infection, respectively.

From the foregoing observation it appears that the different parent varieties and their combinations seem to show a certain degree of difference in their reaction to infection of the disease since they were planted adjacent to each other and were equally exposed to natural infection. It is interesting to note that of the parent varieties, Carti 42 had the highest percentage of infection and in the combinations in which this variety was used, high degree of infection was also observed. On the other hand, where one of the parent varieties in the

cross was not infected at all or had a very low percentage of infection, the F_1 progenies in the combination had low percentage of infection or were not infected at all.

Observation of the affected plants at maturity, however, showed that the presence of the leaf-gall disease did not affect adversely their growth and yield as may have been noticed in Table 7 to 11 which present their performance. The same observation was true in the case of the parent varieties.

The seemingly different reaction to the disease of the parents and the F_1 generation is significant from the plant breeding point of view because the principal objective of the plant breeder is not only for productiveness but also for resistance to diseases. In the latter objective, the observation seems to indicate the possibility of selecting disease-resistant strains from the combinations that did not show signs of infection.

6. INHERITANCE OF SINGLE CHARACTER IN F_2 GENERATION

The study on inheritance of single characters in this experiment was made on the colors of peduncle and the inner glumes or lemma and palea of the cross between Dinalaga and Fortuna and on the glutinous and nonglutinous character of the kernel or endosperm in the cross between Kinafe and Fortuna.

a. *Peduncle color.*—It may be recalled that in the cross between Dinalaga and Fortuna in which purple and green colors of the peduncle were involved, the purple color was dominant in the F_1 plants. In the F_2 generation, as shown in Table 13,

TABLE 13.—*Inheritance of color of peduncle in F_2 of Dinalaga × Fortuna.*

Progeny number	Total number of plants	Color of peduncle				Chi-squares	Ratio
		Purple		Green			
		Observed	*Calculated*	*Observed*	*Calculated*		
3	579	418	434.25	161	144.75	2.432	2.89 : 1.11
6	150	115	112.50	35	37.5	0.223	3.07 : 0.93
9	186	148	139.50	38	46.5	2.072	3.18 : 0.82
10	143	119	107.25	24	35.75	5.149	3.33 : 0.67
Total	1,058	800		258		9.876	3.02 : 0.98

Df = 4; P = <0.05

segregation of purple and green peduncle in the first three progenies was within the 3:1 ratio. On the other hand, the last progeny had a rather large deviation which made the value of the total X^2 with 4 degrees of freedom slightly significant, indicating that a disturbing factor was present. The significant deviation of the total population from the expected

ratio might have been due to the cumulative effect of the deviations from each progeny as a result of planting only a portion of the seeds. However, the fact that three out of the four progenies had insignificant values of X^2 seems to indicate a strong evidence that these characters behaved as a single Mendelian factor.

b. Color of inner glumes or lemma and palea.—It was mentioned previously that while Dinalaga and Fortuna had generally straw-colored inner glumes except for a slight purple tinge in Fortuna, their combination produced F_1 plants with dark-purple inner glumes. Table 14 shows that the F_2 generation segre-

TABLE 14.—*Inheritance of color of inner glumes in F_2 generation of a cross between Dinalaga and Fortuna.*

Progeny number	Total number of plants	Color of inner glumes				Chi squares	Ratio
		Dark purple plus light purple		Straw			
		Observed	*Calculated*	*Observed*	*Calculated*		
3	579	322	325.69	257	253.31	0.096	8 90 : 7.10
6	150	91	84.38	59	65.62	1.187	9.71 · 6.29
9	186	117	104.63	69	81.37	3.343	10.06 : 5.94
10	143	88	80.44	55	62.56	1,625	9.85 : 6 15
Total	1,058	618		440		6.251	

Df = 1, P = >0.10

gated into plants with purple and straw inner glumes in an approximate ratio of 9:7. This observation may be attributed to the interaction of the genes possessed by both parents. In this case, it may be assumed that each parental variety had a dominant gene for purple color of these parts which does not have a visible influence upon its recessive allel. Dinalaga might have the gene which may be complementary to the gene possessed by Fortuna. The combination of the two dominant genes in the cross produced dark-purple lemma and palea in the F_1 generation which color segregated into purple and straw in the F_2 generation. That Dinalaga possessed a gene complementary to that of Fortuna may be deduced from the fact that out of the four varietal crosses in which straw-colored inner glumes were involved, only the combination between Dinalaga and Fortuna produced plants with dark-purple color in the F_1 generation.

The goodness of fit of the two class frequencies to this kind of gene interaction may be seen in the insignificant values of the X^2 of the deviations of individual progenies as well as that of the total population of the different progenies.

A similar gene interaction and mode of inheritance was reported by Kato (1916), as cited by Jones (1936), in that a ratio of 9 red to 7 white was observed from a cross between varieties with white inner glumes.

c. Nature of kernel.—In the cross Kinafe × Fortuna seeds of individual F_1 plants segregated into nonglutinous and glutinous kernels. It is interesting to note, as shown in Table 15, that individual F_2 generation plants segregated into three classes, namely, (*a*) those that produced both nonglutinous and glutinous kernels; (*b*) those whose kernels were purely glutinous; and (*c*) those that were purely nonglutinous.

TABLE 15.—*Inheritance of kernel characters of F_2 plants from a cross between Kinafe and Fortuna*

Progeny number	Total number of plants	Character of kernel of individual plant: Nonglutinous and glutinous		Glutinous		Nonglutinous		Chi-squares	Ratio
		Observed	*Calculated*	*Observed*	*Calculated*	*Observed*	*Calculated*		
2	173	96	97.3125	21	32.4375	56	43.250	7.810	8.68:1.94:5.18
3	109	54	61.3125	17	20.4375	38	.27 250	5.691	7.94:2.5 :5.56
5	121	68	68.0625	18	22.6875	35	30.250	1.714	8.99:2.38:4 63
Total	403	218	-------	56	--------	129	--------	15.215	-------

Df = 6, P = <0.05

This mode of inheritance is at variance with the findings of Ikeno (1914), Hoshino (1915), Kato (1916), and Yamaguchi (1918), as cited by Jones (1936), in that these investigators found a ratio of 3 starchy to 1 glutinous in the F_2 generation in crosses involving starchy and glutinous endosperm.

In the present study in which the mother plant had glutinous kernels instead, the deviation of the class frequencies from a 9:3:4 ratio was rather high as the polled X^2 had a value greater than the 5 per cent level. This significant value of the deviations from 9: 3: 4 ratio might have been due to discrepancy in the determination of the character of the kernel. As only twenty grains at least in each plant were hulled for examination of the character of the kernel, it might have been probable that this number was not sufficient to give the true character of the kernel of the individual plants. This is shown by the fact that the observed plants with nonglutinous kernels were, in all cases, very much higher than the calculated. It might also be probable that certain factors might have entered into the manner of inheritance of these characters. The data, however, seem to show evidence that the three class frequencies had the tendency

to be within the above-mentioned ratio as the value of the X^2 for the total population did not exceed the 1 per cent level.

7. INHERITANCE RELATION OF CHARACTERS

a. Hairiness or glabrousness of leaf and inner glumes.—In the crosses between Caawa II, Dinalaga, C45–1, and C45–2 with that of Fortuna in which the maternal parents had smooth leaf and smooth inner glumes, and Fortuna, hairy leaf and inner glumes, all the F_1 progenies had hairy leaves and inner glumes. Assuming that the two factor pairs were inherited independently, the second generation offsprings of the different crosses should have segregated into a phenotypic ratio of 9 hairy leaf with hairy inner glumes, 3 hairy leaf with smooth inner glumes, 3 smooth leaf with hairy inner glumes, and 1 smooth leaf with smooth inner glumes. The data in Table 16, however, do not seem to agree with the expected segregation ratio as shown by the fact that each progeny of the varietal crosses had only two classes, namely, hairy leaf with hairy inner glumes and smooth leaf with smooth inner glumes. The class frequencies in the progenies of the different combinations seem to show that the two factor pairs behaved like a simple Mendelian character. The insignificant values of the X^2 of each progeny as well as the polled X^2 of the different progenies seem to point out the fitness of the class frequencies to the ratio of 3:1.

TABLE 16.—*Interrelation of hairy characters of leaf and inner glumes in F_2 generation of different crosses.*

Varietal combinations	Total number of plants	Number of plants with— Hairy leaf and inner glumes: Observed	Hairy leaf and inner glumes: Calculated	Smooth leaf and inner glumes: Observed	Smooth leaf and inner glumes: Calculated	Calculated ratio	Chi-squares
Caawa II × Fortuna 2	345	264	258.75	81	86.25	3.06:0.94	0.427
Caawa II × Fortuna 5	138	106	103.50	32	34.50	3.07:0 93	0.421
Caawa II × Fortuna 7	589	428	441.75	161	147.25	2.91:1.09	1.712
Dinalaga × Fortuna 3	579	429	434.25	150	144.75	2.96:1.04	0.253
Dinalaga × Fortuna 6	150	120	112.50	30	37.50	3.20:0.80	2 000
Dinalaga × Fortuna 9	186	141	139.50	45	46.50	3.03:0.97	0.064
Dinalaga × Fortuna 10	143	110	107.25	33	35.75	3.08:0.92	0.283
C45-2 × Fortuna 2	212	169	159.00	43	53.00	3.19:0.81	2.516
Total	2,342	1,767		575			7.496

Df = 4: P = >0.50

From the foregoing, it may be pointed out that hairiness or glabrousness of the leaf and inner glumes is inherited together, for in no case was a plant found to have hairy leaf and glabrous inner glumes and vice versa. It is probable that only one gene is responsible for these characters, or the genes controlling them are completely linked.

TABLE 17.—*Relationship of the color of stigma and apiculus in F_2 generation of Dinalaga × Fortuna*

Progeny number	Total number of plants	Number of plants with— Purple stigma and purple apiculus		Green stigma and slightly purple apiculus		Calculated ratio	Chi-squares
		Observed	*Calculated*	*Observed*	*Calculated*		
3	579	443	434.25	136	144.75	3.06:0.94	0.7052
6	150	110	112.50	40	37.50	2.93:1.07	0.2221
9	186	149	139.5	37	46.50	3.20:0.80	2.586
10	138	102	103.5	36	34.5	2.96:1.04	0.0869
Total	1,053	804	----------	249			3.6002

Df = 4; P = <0.50

b. Color of stigma and apiculus.—The relationship of the color of stigma and apiculus of Dinalaga × Fortuna as presented in Table 17 show that in all cases the different progenies segregated into two class frequencies, namely, (1) plants with purple stigma and apiculus and (2) those whose stigma was green, and apiculus, slightly purple.

The above observations are different from those observed in the cross between Caawa II and Fortuna as shown in Table 18. In this combination, while the stigma and apiculus of Caawa II are both white, and that of Fortuna, both purple, the resulting F_2 generation segregated into three classes, the original colors of stigma and apiculus of the parents and a combination of green stigma, and purple apiculus. The proportion of these classes was statistically within the 9:3:4 ratio. No plant having purple stigma and white apiculus was observed.

The foregoing results seem to point to a possibility that the colors of stigma and apiculus are inherited together and the deviation from the original colors of the parent varieties might have been due to possible interaction or crossing over of the genes responsible for these characters.

TABLE 18.—*Inheritance of stigma and apiculus color in F_2 generation of Caawa II × Fortuna*

Progeny number	Total number of plants	Number of plants with— Purple stigma and apiculus		White stigma and apiculus		White stigma and slightly purple apiculus		Chi-squares
		Observed	*Calculated*	*Observed*	*Calculated*	*Observed*	*Calculated*	
2	344	198	193.50	47	64.50	99	86	6.8176
5	138	69	77.625	23	25.875	46	34.50	5.107
6	163	84	91.6875	34	30.5625	45	40.75	1.474
7	589	330	331.3125	105	110.4375	154	147.25	0.582
Total	1,234	681	----------	209	----------	344	----------	13.9806

Df = 8; P = <0.10

8. AGRONOMIC CHARACTERS IN F_2 GENERATION

As yield is one of the ultimate goals in rice improvement, this factor bears an important rôle as a basis in determining the merits of each of the different varietal combinations. However, other agronomic characters that tend to modify yield such as tillering capacity, resistance or susceptibility to drought and diseases were also considered.

a. Tillering power of plants.—The tillering capacity of the different parent varieties was obtained by counting at random the tillers of fifty plants in each of the five randomized plots planted to them, while those of the F_2 generation hybrid plants were obtained by counting the tillers of all the plants in each combination. The results are presented in Table 19.

It may be seen in the table that larger percentages of plants producing greater number of tillers per hill were obtained from several combinations than from the parent varieties. For example, in the cross Caawa II × Fortuna, 17.24 per cent of the F_2 plants produced 10 or more tillers, while only 6 and 2.4 per cent, respectively, of the parent varieties produced the above number of tillers. In the case of Carti 42 × Fortuna and its reciprocal cross, the combinations did not give higher percentages of plants producing 10 or more tillers than Carti 42, but they produced higher percentages of plants with greater number of tillers than Fortuna.

TABLE 19.—*Percentages of plants bearing certain number of tillers in parent varieties and crosses, F_2 generation.*

Parent varieties and crosses	Total number of plants	Number of bearing culms per plant				
		1	2	3	4	5
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Caawa II	250	0	0.80	10.40	11.60	9.20
Caawa II × Fortuna	642	2.09	9.27	14.07	13.66	9.46
Carti 42	250	0	0.80	2.80	8.00	10.80
Carti 42 × Fortuna	620	1.52	8.45	22.57	19.34	17.50
Fortuna	250	0.80	9.20	21.10	22.80	19.20
Fortuna × Carti 42	576	1.82	7.43	11.20	17.34	14.88
Dinalaga	250	0.80	1.60	9.20	14.00	20.00
Dinalaga × Fortuna	470	2.32	14.82	27.28	18.12	14.92
C45-2	250	1.20	7.60	23.60	21.20	22.40
C45-2 × Fortuna	620	1.52	8.45	22.57	19.34	17.50
Kinafe	250	0	7.60	26.80	21.60	16.80
Kinafe × Fortuna	399	2.32	14.83	27.23	18.12	14.92
C45-1 × Fortuna	267	1.12	2.62	8.24	13.11	12.73

TABLE 19.—*Percentage of plants bearing certain number of tillers in parent varieties and crosses, F_2 generation.*—Continued

Parent varieties and crosses	Total number of plants	Number of bearing culms per plant				
		6	7	8	9	10
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Caawa II	250	22.0	13.20	10.40	6.40	6.00
Caawa II × Fortuna	642	11.52	8.40	9.22	4.91	17.24
Carti 42	250	10.00	14.40	11.60	11.60	30.00
Carti 42 × Fortuna	620	12.78	6.71	5.18	3.16	2.66
Fortuna	250	10.80	9.20	3.60	0.40	2.40
Fortuna × Carti 42	576	11.52	8.45	8.52	5.48	13.32
Dinalaga	250	12.80	16.40	6.60	7.20	11.20
Dinalaga × Fortuna	470	8.81	5.52	4.29	.86	3.23
C45-2	250	10.80	6.00	3.20	.80	3.20
C45-2 × Fortuna	620	12.78	6.71	5.18	3.16	2.66
Kinafe	250	12.80	6.40	2.80	1.60	1.60
Kinafe × Fortuna	399	8.81	5.52	4.29	0.86	3.23
C45-1 × Fortuna	267	12.32	14.23	11.98	6.74	16.85

Based on the observations presented in the table, there seems to be a greater possibility of selecting strains with high tillering capacity in the combinations Caawa II × Fortuna, Fortuna × Carti 42, and C45–1 × Fortuna.

b. Comparative mean yields of parent and varietal crosses.—The data presented in Table 20 show that the mean yield of the F_2 progenies of the different combinations and those of the parent varieties differed markedly. The lowest mean yield of varietal combinations, 17.90 grams per plant, was obtained from the cross between C45–1 × Fortuna, while the highest, 32.09 grams per plant, was produced from C45–2 × Fortuna. Dinalaga × Fortuna produced the second highest mean yield, 28.58 grams per plant. Of the parent varieties, Dinalaga produced the highest mean yield, 32.15 grams per plant, and Caawa II, the lowest, 16.51 grams per plant.

TABLE 20.—*Comparative mean yield in grams per plant of parent varieties and their combinations in F_2 generation*

Progeny plot	Caawa II × Fortuna	Dinalaga × Fortuna	Fortuna × Carti 42	Carti 42 × Fortuna	Kinafe × Fortuna	C45-1 × Fortuna	C45-2 × Fortuna
1	20.33	24.74	21.84	20.43	20.01	15.88	32.90
2	16.00	25.90	28.80	25.37	14.71	17.02	28.37
3	38.40	35.05	20.31		30.20	21.81	35.05
4			17.57				32.04
5							
Total	74.73	85.69	88.52	45.80	64.92	53.71	128.36
n	3	3	4	2	3	3	4
Mean	24.91	28.56	22.13	22.90	21.64	17.90	32.09
SX^2	2,143.87	2,511.38	2,027.63	1,061.02	1,528.82	90.34	4,142.33

TABLE 20.—*Comparative mean yield in grams per plant of parent varieties and their combination in F_2 generation.*—Continued

Progeny plot	Fortuna	Carti 42	Dinalaga	Caawa II	Kinafe	C45–2	Total
1	35.88	33.00	31.18	12.34	22.86	22.40	
2	25.68	29.64	33.28	12.82	22.14	33.54	
3	20.86	18.80	38.98	19.52	19.86	23.12	
4	27.40	32.62	32.52	12.36	15.78	32.56	
5	21.56	26.32	24.80	26.00	20.34	24.28	
Total	130.88	140.38	160.76	83.04	100.98	135.90	1,293.67
n	5	5	5	5	5	5	52
Mean	26.18	28.08	32.15	16.61	20.20	27.18	
SX^2	3,561.94	4,077.78	5,271.78	1,526.43	2,069.90	3,810.90	34,714.12

ANALYSIS OF VARIANCE

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Total	51	2,529.85		
Between parent varieties and crosses mean	12	1,266.40	105.53	3.26 *
Between progenies of same cross and parents	39	1,263.45	32.40	

The table also shows that of the parent varieties, Dinalaga and Carti 42 produced mean yields as high as that of the combinations between Dinalaga and Fortuna, and C45–2 × Fortuna. Caawa II, Kinafe, and C45–2, however, produced lower mean yields than the combinations in which they were used.

The analysis of variance shows significant differences between means of the varietal combinations and their parent varieties. Based on yield, it seems that in the F_2 generation, the crosses C45–2 × Fortuna, and Dinalaga × Fortuna were the more promising combinations among the different varietal crosses.

c. Uniformity of maturity.—The data presented in Table 21 show that in most cases the F_2 generation of the different combination was harvested at different dates which shows the ununiformity of maturity of the F_2 plants. It is interesting to note, however, that the F_2 plants of C45–2 × Fortuna were uniform in maturity, that they were harvested at the same time (Plate 3, fig. 1). Kinafe × Fortuna was also fairly uniform.

The table also shows that three varietal combinations produced normal plants that were very late that they were not able to produce flowers due to drought (Plate 3, fig, 4). Early strains, however, can be possibly selected from the combination between Caawa II and Fortuna.

d. Infection of streak and leaf gall diseases of rice.—In the first-generation leaf gall disease on rice was observed in both the parents and varietal crosses. Table 22 shows the observa-

tion in the F_2 generation of the infection of diseases which, according to Mr. Julian A. Agati, assistant plant pathologist, were streak and leaf-gall diseases of rice on the same plant. Both diseases are caused by virus.

TABLE 21.—*Uniformity of maturity of different varietal crosses.*

Varietal crosses	Date of harvesting	Remarks
Caawa II × Fortuna	Sept. 15, 1948 Sept. 20, 1948 Oct. 1, 1948 Oct. 13, 1948 Oct. 21, 1948	Very ununiform.
Dinalaga × Fortuna	Oct. 2, 1948 Oct. 9, 1948 Oct. 23, 1948 Oct. 27, 1948	Very ununiform.
Kinafe × Fortuna	Oct. 4, 1948 Oct. 15, 1948	Fairly uniform.
Fortuna × Carti 42	Oct. 15, 1948 Oct. 22, 1948 Oct. 28, 1948	Ununiform and 7 normal plants were very late and did not produce flowers.
Carti 42 × Fortuna	Oct. 15, 1948 Oct. 21, 1948 Oct. 28, 1948	Ununiform and 3 normal plants were very late and did not produce flowers.
C45-1 × Fortuna	Oct. 8, 1948 Oct. 21, 1948 Oct. 28, 1948 Nov. 2, 1948	Ununiform and 128 normal plants were very late and did not produce flowers.
C45-2 × Fortuna	Oct. 12, 1948	Very uniform.

TABLE 22.—*Infection of streak-leaf gall disease of rice in some progenies of varietal crosses.*

Progenies of varietal crosses affected	Number of plants infected	Number of tillers per plant	Number of normal tillers	Number of tillers affected	Per cent of inhibition of panicle production
C45-2 × Fortuna No. 3	1	12	0	12	100.0
	2	10	0	10	100.0
	3	16	0	16	100.0
	4	13	0	13	100.0
	5	8	0	8	100.0
	6	14	0	14	100.0
	7	13	0	13	100.0
	8	8	1	7	87.5
	9	11	0	11	100.0
	10	7	0	7	100.0
	11	9	0	9	100.0
	12	6	2	4	66.7
	13	13	0	13	100.0
	14	9	0	9	100.0
	15	9	2	7	77.8
	16	5	0	5	100.0
	17	10	1	9	90.0
	18	6	4	2	33.3
	19	12	0	12	100.0
	20	7	1	6	85.7
	21	15	7	8	53.3
	22	8	3	5	62.5
	23	9	0	9	100.0
	24	13	2	11	84.6
	25	19	1	18	94.7
	26	4	0	4	100.0
	27	2	0	2	100.0
Average					90.2

TABLE 22.—*Infection of streak-leaf gall disease of rice in some progenies of varietal crosses.*—Continued

Progenies of varietal crosses affected	Number of plants infected	Number of tillers per plant	Number of normal tillers	Number of tillers affected	Per cent of inhibition of panicle production
Fortuna × Carti 42 No. 7	1	11	2	9	81.8
	2	7	5	2	28.6
	3	4	2	2	50.0
Average					53.5
Kinafe × Fortuna No. 5	1	4	0	4	100.0
	2	2	1	1	50.0
	3	4	2	2	50.0
	4	4	2	2	50.0
	5	2	0	2	100.0
	6	2	0	2	100.0
	7	3	2	1	33.3
	8	6	0	6	100.0
	9	2	1	1	50.0
Average					70.4
C45-1 × Fortuna No. 7	1	8	0	8	100.0
	2	4	0	4	100.0
	3	4	0	4	100.0
	4	3	2	1	33.3
	5	3	0	3	100.0
	6	3	0	3	100.0
	7	5	1	4	80.0
Average					87.6
Kinafe × Fortuna No. 3	1	3	2	1	33.3
	2	4	2	2	50.0
Average					41.7
Fortuna × Carti 42 No. 2	1	8	0	8	100.0
	2	5	0	5	100.0
	3	9	2	7	77 8
	4	4	0	4	100,0
	5	3	0	3	100.0
	6	7	0	7	100.0
	7	16	6	10	62.5
	8	9	2	7	77.8
	9	8	3	5	62.5
Average					86 7

Examination of the table shows that out of a total of 22 progenies of the different combinations planted, only 6 were infected with the diseases. It should be mentioned in this connection that the diseases were observed in varietal progenies planted in different portions of the field. It is significant that varietal combinations, such as Dinalaga × Fortuna No. 9, C45–2 × Fortuna No. 2, and Caawa II × Fortuna No. 5 that were planted adjacent to the badly infected ones, like C45–2 × Fortuna No. 3, C45–1 × Fortuna No. 7, and Kinafe × Fortuna No. 5, were free from infection. It is also significant that these diseases were not observed among the parent varieties.

It may be seen further that while in most cases the infected plants did not produce any panicle, others were able to develop one or two normal panicles (Plate 4, figs. 1 and 2). This

observation may point to at least three possibilities, namely, (*a*) either the concentration of the virus in the infected plant that produced a normal panicle might not have been sufficient to have completely inhibited the development of the panicle, (*b*) at the inception of the diseases the tiller producing the normal panicle in an infected plant might have been far advanced in its development that the diseases were no longer destructive to the particular tiller, and (*c*) the bud producing the normal panicle might have a certain degree of vigor or probably resistance that it was able to develop normally in spite of the presence of the diseases. Under the last possibility, the seeds of the normal panicle from plants that were badly infected may be of inestimable value as materials for study in connection with resistance to the disease.

SUMMARY AND CONCLUSIONS

This paper is a report on the results of the first part of an experiment to improve the yield of upland rice varieties by artificial hybridization. It deals principally on the technique of hybridization used and the behavior of certain characters in the F_1 and F_2 generation plants of different varietal crosses. Such characters are color of the leaf-sheath, peduncle, and parts of the grain; glutinous or nonglutinous character of the endosperm; glabrousness or hairiness of the leaf-blade and inner glumes; length of maturity; nature of growth of tillers; vigor of the different varietal combinations as expressed by height, number of bearing culms per plant, average length of panicle, number of grains per panicle, yield per plant; and reaction to natural infection of streak and leaf-gall diseases of rice.

From the results of this experiment the following conclusions may be drawn:

1. The percentage of developed and matured emasculated florets ranged from 20.8 to 70 in the crosses C45–1 × Fortuna, and Dinalaga × Fortuna, respectively.

2. Hybrid grains from emasculated flowers stored in air-tight vials for about seven to eight months had an average germination of 97.9 per cent when sown directly in unsterilized garden soil, while those that were soaked for 24 hours and incubated for another 24 hours before sowing in the same kind of germinating medium gave 93.8 per cent.

3. In all cases where green and purple or red colors of morphological parts are involved in a cross, the purple colors were always dominant over the green in the F_1 plants. Likewise

hairiness of the leaf-blade and inner glumes was dominant over glabrousness.

4. In size and shape of the grain the F_1 progenies were intermediate between the two parents.

5. In a cross between glutinous and nonglutinous varieties, the seeds of the same plant segregated in the F_1 generation into approximately 3 nonglutinous to 1 glutinous kernels.

6. The spreading characteristic of the tiller and rachillae of the panicle was dominant over the close or nonspreading character.

7. In earliness of maturity the F_1 hybrid plants were intermediate between the two parents, but more toward the earlier-maturing variety.

8. The different varietal combinations with one variety as a common parent differed significantly in vigor as expressed by height, number of bearing culms, length of panicle, number of grains per panicle, and yield per plant in the F_1 generation.

9. Parent varieties and F_1 plants of the different varietal crosses differed in susceptibility to natural infection of leaf-gall disease of rice.

10. The mode of inheritance in F_2 generation of the characters studied may be summarized as follows:

a. Purple × green peduncle—single factor difference.

b. Straw × straw with slight purple tinge inner glumes—probably the parent varieties, Dinalaga and Fortuna had complementary dominant genes which produced approximately 9 purple to 7 straw-colored inner glumes.

c. Glutinous × nonglutinous kernel—the mode of inheritance followed an approximate ratio of 9 nonglutinous and glutinous; 3 purely glutinous; and 4 purely nonglutinous kernels.

d. Complete linkage seems to exist between hairiness or glabrousness of leaf and inner glumes.

e. Color characters of stigma and apiculus seem to be closely associated in inheritance.

11. Greater percentages of plants producing high number of tillers per plant than the parent varieties were observed in several combinations.

12. Based on mean yield per plant in the different crosses, C45–2 × Fortuna and Dinalaga × Fortuna seem to be the most promising combinations.

13. Uniform maturing plants were obtained in F_2 generation from the cross C45–2 × Fortuna while other varietal combinations were observed to be very ununiform in maturity.

14. Streak and leaf gall diseases of rice were observed in some of the progenies in the F_2 generation of four varietal combinations. The disease inhibited partially or completely the production of normal panicles in the plants affected.

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ILLUSTRATIONS

Plate 1

Showing the height of F_1 progenies of a cross between Carti 42 and Fortuna.

Plate 2

Showing the increased length of panicle of the F_1 progenies of upland crosses. *1*, Caawa II; *2*, Caawa II × Fortuna; *3*, Fortuna; *4*, Kinafes; *5*, Kinafe × Fortuna; *6*, Fortuna.

Plate 3

Fig. 1. Showing uniformity of flowering and height of the cross C45–2 × Fortuna in F_2 generation.

2. Showing ununiform flowering and height of the cross Fortuna × Carti 42. Note that some plants have already flowered while others have not.

Plate 4

Fig. 1. Showing inhibition of flowering and panicles production caused by the streak and leaf-gall diseases in cross C45–2 × Fortuna.

2. A close-up of a plant of the cross C45–2 × Fortuna showing dwarfing and total inhibition of panicle production due to streak and leaf-gall diseases of rice.

PLATE 1

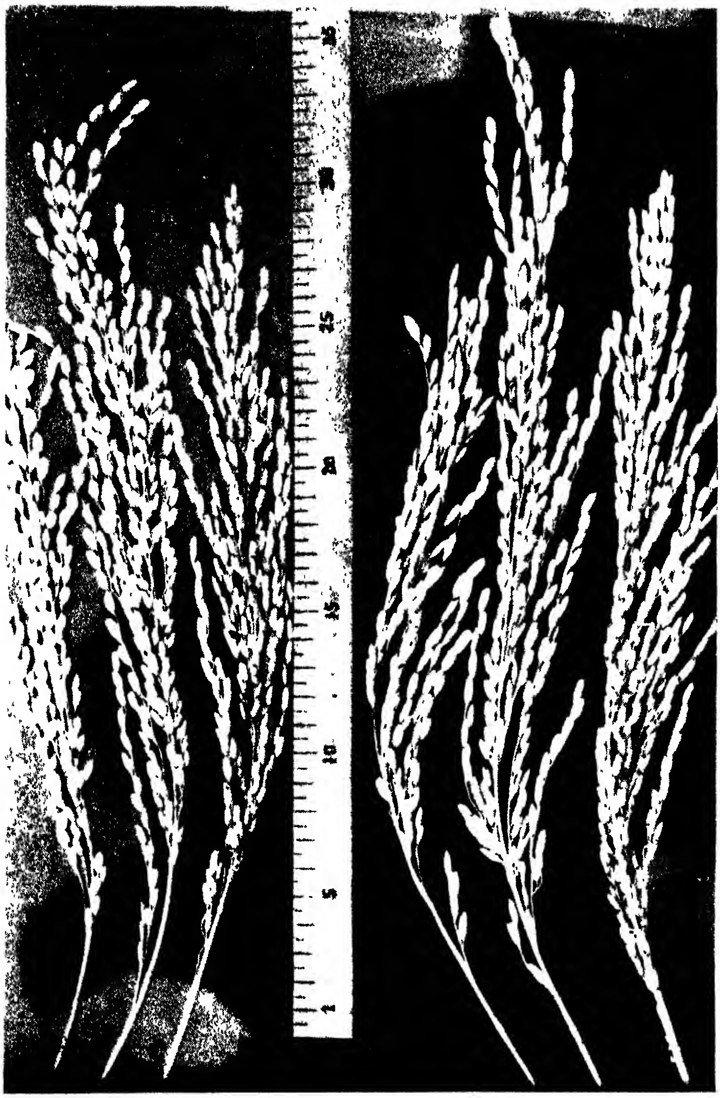

PLATE 2

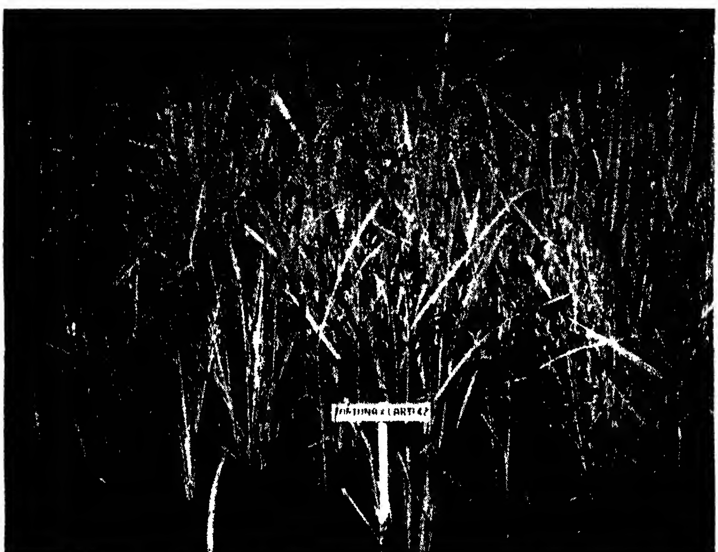

PLATE 3

PLATE 4

ERRATA

Page 43, footnote d. *For* $= \frac{60.11}{0.97} = 62$ cavanes per Ha *read* $= \frac{60.11}{0.97} = 62$ cavans per Ha.

Page 96, line 3. *For* wrapped *read* wrapper.

Page 110, line 33. *For* absolutedly *read* absolutely.

Page 132, line 22. *For* Begonia de Man *read* Begonia de Mano.

Page 135, last paragraph. For the first sentence *read* The begonias are commercially propagated by asexual means; however, if new strains or types of begonias are desired, the sexual method of propagation may be resorted to.

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